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Intermountain GeoEnvironmental Services, Inc.
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SX/EW Raffinate and Preg Solution Pond Technical Report and Permit Application

IGES Job No. 01640-002

April 8, 2014

Prepared for:

CS Mining
P.O. Box 608
Milford, Utah 84751

Document Date 4/9/2014
DWQ-2014-005168

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April 8, 2014

State of Utah – Department of Environmental Quality
Division of Water Quality
288 North 1466 West
P.O. Box 144870
Salt Lake City, Utah 84111-4870

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APR 09 2014
Utah Division of Water Quality

Attention: Mr. Woodrow W. Campbell, P.E.

Subject: CS Mining, LLC
Double Lined Raffinate and PLS Pond Permit
West of Milford, Utah

The attached design plans and construction specifications are submitted for your review and approval addressing the addition of double lined ponds with leak detection associated with the proposed acid leach circuit and SX/EW additions to the process plant at the CS Mine near Milford, Utah. This permit submittal is associated with the documents previously submitted for intermediate tailings dam facility (ITDF) and other documents related to process units and concrete works associated with the proposed acid leach circuit.

As the drawings show, we are proposing the use of an XR-5 material for lining the ponds. Information on the chemical compatibility characteristics and other material properties of the XR-5 material is provided in an Appendix to this submittal. A double lined system with leak detection is proposed because of the chemical composition of the fluids to be contained.

Although the ponds are joined by a common embankment, individually each will contain less than 20 acre-feet of storage capacity and will not pose a threat to human life, consequently, the dams will meet the requirements of a low hazard dam and a simple application as such will be submitted to the Division of Dam Safety in concert with this application submittal to DWQ.

Should you have any questions, please do not hesitate to call me at (801)-270-9400 or my cell (801)-243-9603.

Respectfully submitted,
IGES, Inc.

PROFESSIONAL ENGINEER
157987
JOHN F. WALLACE
04/09/2014
ELECTRONIC SEAL
STATE OF UTAH

John F. Wallace, P.E., D.GE.
Principal

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1.0 EXECUTIVE SUMMARY

CS Mining plans to expand it's mining operations and modify its processing plant to include an acid-leach solvent extraction and electrowinning (SX/EW) circuits. As part of the process, raffinate and pregnant leach solution (PLS) ponds will be required. One pond of each type is proposed. The ponds will share a common central embankment and be mirror images of each other, with storage capacities slightly less than 20 acre-ft. and maximum operating depths of 20 feet.

The purpose of this report is to demonstrate the technical feasibility of the proposed pond system and present detailed engineering plans supporting the proposed design approach.

A double lined containment system with leak detection is proposed for each pond. Pond lining will consist of a 38 mil 8138 XR-5 primary liner over a 30 mil 8130 XR-5 secondary liner. A drainage net will be placed between the two liner as part of a leak detection system. An 8 ounce non-woven geotextile will be placed below the secondary liner as a cushion. A leak detection sump with accompanying monitor well and pump will be installed at the lower corner of each pond.

Raffinate and pregnant solutions will be recovered from the ponds via a dedicated pumping system near the lower corner of each pond.

Source of borrow soils to be used for the proposed pond construction will be developed immediately from the pond excavations and if required from a borrow area immediately west of the pond site at the possible location of a similarly constructed future third pond.

NOTICE: The scope of services provided within this report are limited to the assessment of the subsurface conditions at the subject site. The executive summary is provided solely for purposes of overview and is not intended to replace the report of which it is part and should not be used separately from the report.

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2.0 INTRODUCTION

2.1 PURPOSE AND SCOPE OF WORK

This report presents the results of a geotechnical investigation and analyses conducted for the proposed expansion of CS Mining's processing operations, specifically the addition of acid leach and solvent extraction/electrowinning circuits which will include two lined ponds. Geotechnical characterization of the pond sites and proposed borrow materials was performed as a basis for development of the proposed design. The recommendations contained in this report are subject to the limitations presented in the "Limitations" section of this report.

2.2 PROJECT DESCRIPTION

The leach process begins with the delivery of thickened acid leach feed from the tailings thickeners in the flotation mill to the leach circuit along with raffinate (recycled leach solution depleted of metals in the SX circuit, recovered from the raffinate pond) and sulfuric acid to adjust the pH in the first leach tank. Leaching of flotation tailings takes place as they flow through a series of 7 agitated leach tanks at progressively lower rates with addition of acid at each tank to maintain proper pH before flowing to the counter current decantation (CCD) tanks where pregnant (metal-bearing) solution is progressively separated from the solids by counter-current decantation, and sent to the PLS pond. The solids, tailings, from the CCD circuit are then pumped to the ITDF. From the PLS, pregnant solution is pumped through the SX circuit. The metal laden solvent is then reacted with concentrated sulfuric acid (in the tank farm area) where metal is separated from the solvent after which the acid solution is pumped to the electrowinning circuit where copper cathodes are produced.

As discussed above, the raffinate and pregnant leach solution ponds are integral parts of the SX/EW circuit. The following sections address the design development of these two ponds.

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3.0 METHODS OF STUDY

3.1 GEOLOGY

The geologic conditions for the site have previously been investigated and discussed by GEM Engineering, Inc. (2009) and are included herein for completeness.

The Beaver Lake Mountains lie within the east-trending belt of alteration and mineralization known as the Warm Springs-Pioche-Marysville Mineral Belt (Rowley, et al, 1979). Mineralization within this belt as well as several others documented in the western U.S. is thought to have deep-seated crustal control, and lie immediately to the west of the Mineral Mountains, a batholith composed of intrusives ranging from granite to diorite in composition and ages as young as 9-12 million years. The area is also at the leading eastern edge of the Late Mesozoic-Early Tertiary Sevier thrust system. The immediate project area can be described as having 2 to 12 feet of alluvium overlying granodioritic bedrock. It does not appear that an apparent active faults exist at the proposed pond sites.

3.2 SUBSURFACE INVESTIGATION

Geotechnical conditions at the site were investigated by IGES Inc. on March 7, 2013. Exploration of the subsurface soil and bedrock conditions was accomplished by excavating test pits to between 3.5 and 7 feet in two potential borrow areas including the pond area. The approximate locations of the test pits completed are shown on the Site Map (Plate A-2). The materials encountered during our investigations were observed and logged by an experienced geotechnical engineer and are presented on the Test Pit Logs, Plates A-3 through A-9. A key to Soil Symbols and Terms is located on Plate A-10.

Disturbed samples were obtained from the materials encountered in the test pits. Bulk bucket samples of potential borrow materials were collected in 5 gallon buckets and sealed with air tight lids for preservation.

All investigation activities and sampling were performed under the direction and supervision of an experienced IGES geotechnical engineer.

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3.3 LABORATORY INVESTIGATION

Representative soil samples were tested in the laboratory to evaluate pertinent physical and engineering properties. Laboratory soil tests consisted of moisture, density, gradation analyses, Atterberg limits tests, laboratory compaction, triaxial compression, direct shear, and hydraulic conductivity tests to aid in characterizing the soils and to develop design parameters for our stability and seepage analyses and for correlation purposes. Strength tests were performed on recompacted bulk samples of proposed borrow materials. The results of the laboratory tests are presented in Appendix B.

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4.0 GEOLOGIC CONDITIONS

4.1 GEOLOGIC SETTING

The site is located immediately south of the Beaver Lake Mountains within the Warm Springs-Pioche-Marysville Mineralization Belt (Rowley, et al, 1979). The project area can be described as having 2 to 12 feet of alluvium overlying diotitic bedrock. Some faulting exists in the area, but no evidence of faulting in the area is reported in the literature or by CSM geologists, who have performed condemnation drilling in the general project vicinity.

Location of the site is at Latitude N 38E 29' 1.10", Longitude W 113E 08' 6.58"

There is no surface water, with the exception of that contained within the tailings impoundment, in the general area. Other than minor groundwater in fractures, groundwater is reported to be at depths greater than 100 feet.

4.2 SEISMICITY

The spectral accelerations mapped as a part of NEHRP/NSHMP generally correspond to a "firm rock" site, known as Site Class B. To account for site effects, the PGA is typically modified using a site coefficient that varies with the magnitude of spectral acceleration, distance to seismic source, and the harmonic mean of the shear wave velocity of earth materials in the upper 30 meters, V_s^{30}.

Based on available laboratory data and estimated shear wave velocities the soils underlying the site are classified as Site Class C ("very dense soil and soft rock").

The 2PE50 accelerations were calculated with the aid of the USGS Seismic Hazard Curves and Uniform Hazard Response Spectra v. 5.1.0 application. Data from the probabilistic hazard curve for the 2% probability of exceedance in 50 years was used to calculate the acceleration for evaluating seismic stability of the proposed impoundment expansion. The 2PE50 ground motion for the site, corrected for site class, has been established as 0.26 g. Details of this analysis are included in Appendix C.

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4.4 OTHER GEOLOGIC HAZARDS

Geologic hazards can be defined as naturally occurring geologic conditions or processes that could present a danger to human life and property. The only potential geologic hazard relevant to the proposed facility modification is liquefaction. This potential hazard is addressed in the following section.

4.4.1 Liquefaction

The general absence of groundwater coupled with the relative dense nature of soils that will underlie the doubly lined ponds and their containment within a engineered compacted earth structure eliminates the potential of liquefaction being a factor in future pond performance.

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5.0 GENERALIZED SITE CONDITIONS

5.1 SURFACE CONDITIONS

Surface conditions at the proposed facility are those of a gently sloping natural hillside immediately west of the existing mill site. The gently sloping sparsely vegetated terrain will limit the embankment height required along the north side of the ponds and provide a source of borrow from within the pond footprint to construct the relatively modest side and southern embankments. Crest elevation of the proposed embankment structure is at EL.5890. Existing ground surface along the north and south embankments presently is 5890 and 5872 respectively.

5.2 SUBSURFACE CONDITIONS

5.2.1 Soils

Subsurface conditions beneath the proposed embankments and lined interior were defined by three of the 5 test pits excavated in the general pond area.

Test pits excavated to characterize the pond site potential borrow area proposed for embankment construction encountered approximately 6 inches of sandy silt with a thin root mat that can be characterized as "topsoil". This veneer of "topsoil" was typically underlain by a medium dense, poorly graded silty sand classifying as an SM to SP-SM, based on the Unified Soil Classification System (USCS). These near surface sands contained some gravel and cobble sized rock fragments of highly to moderately weathered rock and transitioned to the underlying bedrock(granodiorite) generally at depths ranging between 6 and 7 feet..

5.2.2 Bedrock

Depth to bedrock varies across the site ranging from 5 to 11 feet below the existing grade. Weathered bedrock was composed of a granodiorite overlain by a completely decomposed mantel of this parent rock characterized as a gravely sand (GM). A thin veneer of sandy silt with gravel covers these residual soils and weathered bedrock.

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5.2.3 Groundwater

Depth to groundwater at the site is estimated to be in excess of 100 feet below the base of the impoundment.

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6.0 ENGINEERING ANALYSIS AND DESIGN RECOMMENDATIONS

6.1 GENERAL CONCLUSIONS

Supporting data upon which the following recommendations are based have been presented in the previous sections of this report. The recommendations presented herein are governed by the physical properties of the soils encountered in the exploratory test pits. If subsurface conditions other than those described herein are encountered in conjunction with construction, and/or if design and layout changes are initiated, IGES must be informed so that our recommendations can be reviewed and revised as changes or conditions may require.

Based on the subsurface conditions encountered at the site, our literature review of geologic hazards and our engineering analysis, it is our opinion that the proposed construction can be completed provided the designs and recommendation contained within the following sections and attached drawings are properly implemented during construction. We recommend that IGES, Inc. be involved during the construction to see that the recommendations contained in this report are complied with.

6.2 EARTHWORK

Modest general site grading will be required for the proposed construction.

6.2.1 General Site Preparation and Grading

The uppermost 6 inches of soil within the proposed borrow area designated as topsoil should be stripped and stockpiled for use in future reclamation activities. Site preparation of the embankment footprint area, subsequent to clearing, grubbing and topsoil removal will require proof rolling to identify any soft of unsuitable foundation conditions. If any such conditions are encountered, over-excavation, replacement and compaction of the excavated soils will be required. All other areas of the proposed embankment foundation area shall be scarified, moisture conditioned and compacted to the requirements of structural fill as discussed in the following section, prior to placement of the initial lift of engineered embankment fill.

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6.2.2 Structural Fill and Compaction

Most fill placed in conjunction with development of the pond embankments will consist of compacted structural fill from within the pond or a designated borrow site. Fill materials shall be free of major root matter, other organics, frozen soils, boulders, large cobbles (>6"), debris or other deleterious materials.

All structural fill placed above and including the foundation preparation, shall be placed in maximum 12- inch loose lifts and compacted on a horizontal plane, unless otherwise approved by the Geotechnical Engineer. Structural fill should be compacted to at least 95 percent of the maximum dry density, as determined by ASTM D-698. The moisture content should be within +/- 2 percent of optimum at the time of compaction. Any borrow materials proposed should be approved prior to importing.

6.2.3 Leak Detection Sump Fill

The leak detection sump area will consist of relatively clean, free-draining gravel fill. The gravel fill shall be ½" minus and have a maximum P_{200} not greater than 5%. These drainage materials should be paced in loose lifts generally not exceeding 8 inches and compacted using vibratory compaction equipment to 80% of the maximum relative density determined per ASTM D-4253.

6.3 EMBANKMENT ANALYSES

6.3.1 Seepage Analyses

Seepage analyses were not performed for the embankments since the ponds will be a fully and doubly lined system with leak detection.

6.3.2 Stability Analyses

Lab testing data were reviewed to select representative material properties for modeling the dike section(s) selected for stability analyses. Soil properties for the proposed borrow material were generalized from laboratory testing conducted and summarized in Appendix B. The following

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summarizes the general material properties assigned for the analyses of the proposed embankments.

Foundation soil

Total unit weight – 130 pcf
Effective Phi – 34 degrees
Effective cohesion – 100 psf

Embankment Fill – borrowed site soil – EOC - short term

Total unit weight – 130 pcf
Effective Phi – 23 degrees
Effective cohesion – 500 psf

Embankment Fill – borrowed site soil – long term

Total unit weight – 130 pcf
Effective Phi – 34 degrees
Effective cohesion – 100 psf

Analyses

Slope stability analyses were performed using the code SLIDE 6.0 from RocScience. Strength parameters were developed for the generalized stratigraphic profile based on the testing performed during this investigation. In order to determine dike fill strength properties, triaxial tests and direct shear tests of laboratory compacted samples from borings were used to determine a friction angle and cohesion intercept.

A cross-section was developed for the most critical section and was evaluated using compacted silty borrow for the maximum embankment height of 28 feet. An upstream slope of 3.0:1V and downstream slope of 2.5H:1V with a 15 foot crest width was used in the model for the analyses.

Pseudodynamic analyses were performed to evaluate stability under earthquake conditions. For a 2 percent probability of occurrence in 50 years or an approximately 2,400 year return period event, a Peak Ground Acceleration (PGA) of 0.26 g can be calculated for the site, assuming a

site class C designation. A 50% reduction in the PGA was made per recommendations by Hynes and Franklin[1] and others to account for time response effects resulting in a design PGA of 0.13 g.

A summary of the various cases evaluated and the resulting factors of safety determined using SLIDE 6.0 are summarized in the following table.

Summary of Slope Stability Modeling

Description of Analysis Case	Static or Seismic	Factor of Safety	Plate Number
Downstream case – EOC	Static	2.4	C-1
Downstream case –LONG TERM	Static	2.2	C-2
Downstream case – pseudodynamic	Seismic	1.6	C-3

As the results of the analyses presented in the Appendix in Plates C-1 to C-3 all long term static minimum factors of safety calculated are greater than 1.5 and those under design pseudodynamic conditions are greater than 1.0.

6.4 DESIGN RECOMMENDATIONS

The embankments used to form each pond will be developed using fill materials excavated from within the pond footprint and supplemented if necessary using materials from the adjacent borrow area. Upstream slopes in the ponds will be constructed using a 3.0H:1V slope to facilitate liner installation whereas the downstream slopes will be steeper and constructed at 2.5H:1V slope .

The embankment crest width is recommended to be 15 feet to facilitate implementation of wheel berms and trafficability for maintenance equipment. Maximum pond operating depth will be 20 feet. An additional three (3) feet of free board will be maintained for safety.

---

[1] **Hynes-Griffin and Franklin 1984,** Hynes-Griffin, M. E., and Franklin, A. G. 1984. "Rationalizing the Seismic Coefficient Method," Miscellaneous Paper GL-84-13, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

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The recommended double lined containment system includes leak detection. The liner material recommended is an XR-5 product manufactured by Seaman Corporation because of its high chemical resistance, low thermal expansion and contraction and relative high puncture resistance compared to similar thickness EPDM or HDPE. An 8 oz//yd^2 non-woven fabric will be used below the secondary liner to further minimize puncture potential.

The attached set of drawings 1-6 in Appendix D have been developed to depicting the proposed expansion design. Specifications for construction of the proposed raise are provided in Appendix E. Product data sheets for the proposed liner system materials are provided in Appendix F.

7.0 CLOSURE

7.1 LIMITATIONS

The recommendations contained in this report are based on our limited field exploration, laboratory testing, and understanding of the proposed construction. The subsurface data used in the preparation of this report were obtained from the explorations made for this investigation. It is possible that variations in the soil and groundwater conditions could exist between the points explored. The nature and extent of variations may not be evident until construction occurs. If any conditions are encountered at this site that are different from those described in this report, our firm should be immediately notified so that we may make any necessary revisions to recommendations contained in this report. In addition, if the scope of the proposed construction changes from that described in this report, our firm should also be notified. This report was prepared in accordance with the generally accepted standard of practice at the time the report was written. No warranty, expressed or implied, is made.

It is the Client's responsibility to see that all parties to the project including the Contractor, Subcontractors, etc. are made aware of this report in its entirety. The use of information contained in this report for bidding purposes should be done at the Contractor's option and risk.

7.2 ADDITIONAL SERVICES

The recommendations made in this report are based on the assumption that an adequate program of tests and observations will be made during the construction. IGES staff should be on site to

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verify compliance with these recommendations. These tests and observations should include, but not necessarily be limited to, the following:

- Observations and testing during site preparation, earthwork and structural fill placement.
- Consultation as may be required during construction.
- Quality control and observation of fill placement and liner construction.

We appreciate the opportunity to be of service on this project. Should you have any questions regarding the report or wish to discuss additional services, please do not hesitate to contact us at your convenience (801) 270-9400.

Respectfully,
IGES, Inc.

PROFESSIONAL ENGINEER
157987
JOHN F.
WALLACE
04/09/2014
ELECTRONIC SEAL
STATE OF UTAH

John F. Wallace, P.E., D.GE.
Principal

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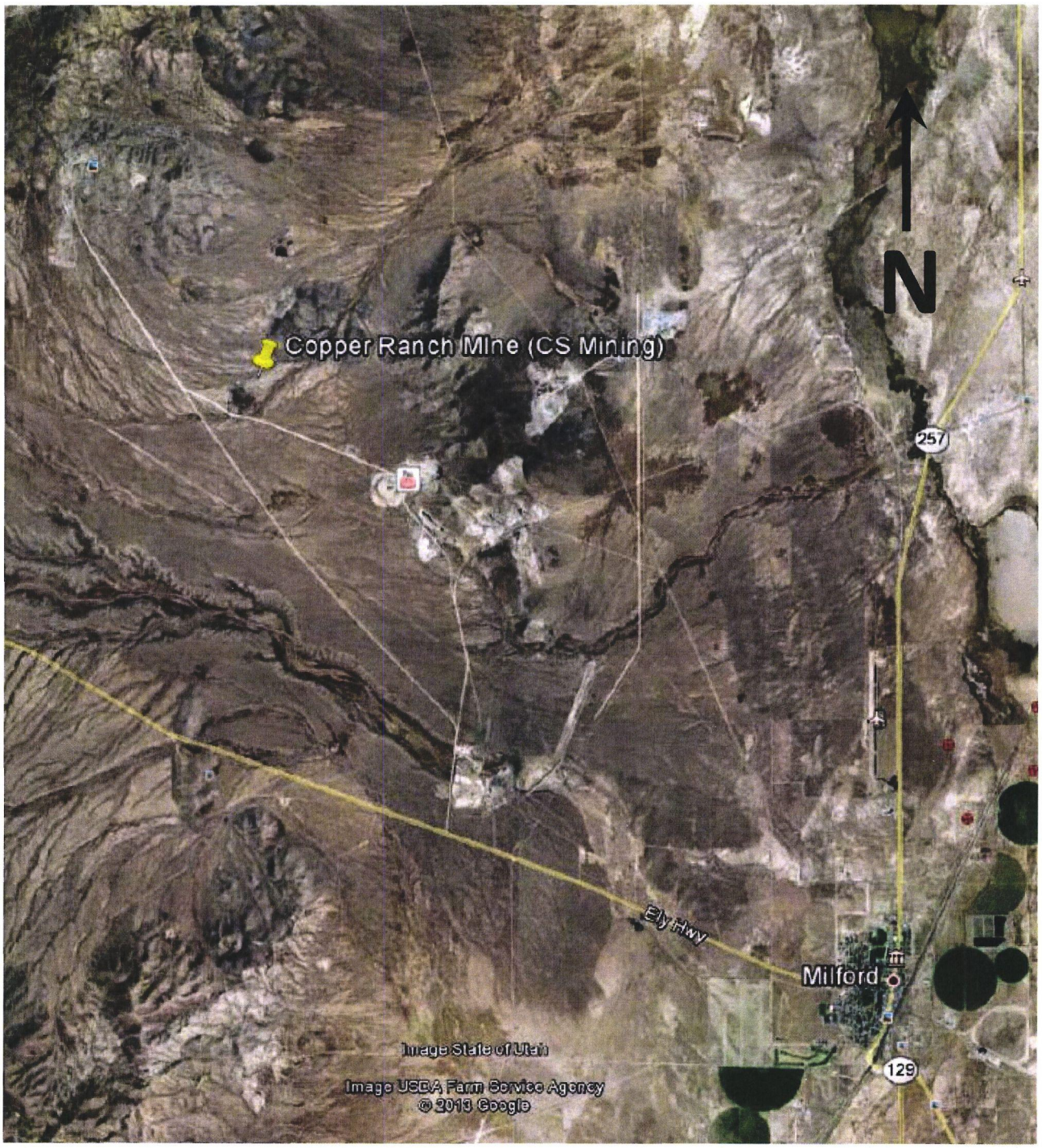
APPENDIX A



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CS Mining Site near Milford, Utah

Vicinity Map

Plate A-1

CS Mining Site near Milford, Utah

Proposed Raffinate and Preg Soultion Ponds

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April 2014

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Test Pit Locations

Plate A-2

DATE		
STARTED:	3/7/13	
COMPLETED:	3/7/13	
BACKFILLED:	3/7/13	

Geotechnical Investigation
CS Mining

Milford, UT — Project Number 01640-001

IGES Rep: NB
Rig Type: Backhoe

TEST PIT NO: **TP-3**
Sheet 1 of 1

LOCATION
Latitude — Longitude — ELEVATION

DEPTH METERS	DEPTH FEET	SAMPLES	WATER LEVEL	GRAPHICAL LOG	UNIFIED SOIL CLASSIFICATION	MATERIAL DESCRIPTION	Dry Density(pcf)	Moisture Content %	Percent minus 200	Liquid Limit	Plasticity Index	Moisture Content and Atterberg Limits (Plastic Limit — Moisture Content — Liquid Limit; 10 20 30 40 50 60 70 80 90)
0	0					TOPSOIL						
					SM	Silty SAND with gravel and cobbles - medium dense, dry, light brown						
1												
	5											
2						Bottom of Test Pit @ 6.5 Feet						
3												

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SAMPLE TYPE
- GRAB SAMPLE
- 3" O.D. THIN-WALLED HAND SAMPLER

WATER LEVEL
- MEASURED
- ESTIMATED

NOTES:

Figure A-3

DATE	
STARTED:	3/7/13
COMPLETED:	3/7/13
BACKFILLED:	3/7/13

Geotechnical Investigation
CS Mining

Milford, UT — Project Number 01640-001

IGES Rep: NB
Rig Type: Backhoe

TEST PIT NO: **TP-4**
Sheet 1 of 1

LOCATION
Latitude — Longitude — ELEVATION

DEPTH METERS	DEPTH FEET	SAMPLES	WATER LEVEL	GRAPHICAL LOG	UNIFIED SOIL CLASSIFICATION	MATERIAL DESCRIPTION	Dry Density(pcf)	Moisture Content %	Percent minus 200	Liquid Limit	Plasticity Index
0	0					TOPSOIL					
					SC	Clayey SAND with gravel and cobbles - medium dense, moist, light brown			31.2	28	11
1											
	5					Clayey SAND with gravel and cobbles - medium dense, moist			14.5	35	12
2						Bottom of Test Pit @ 6 Feet					
3											

Moisture Content and Atterberg Limits
Plastic Limit — Moisture Content — Liquid Limit
10 20 30 40 50 60 70 80 90

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SAMPLE TYPE
- GRAB SAMPLE
- 3" O.D. THIN-WALLED HAND SAMPLER

WATER LEVEL
- MEASURED
- ESTIMATED

NOTES:

Figure A-4

DATE	
STARTED:	3/7/13
COMPLETED:	3/7/13
BACKFILLED:	3/7/13

Geotechnical Investigation
CS Mining

Milford, UT — Project Number 01640-001

IGES Rep: NB
Rig Type: Backhoe

TEST PIT NO: **TP-5**
Sheet 1 of 1

LOCATION
Latitude — Longitude — ELEVATION

DEPTH METERS	DEPTH FEET	SAMPLES	WATER LEVEL	GRAPHICAL LOG	UNIFIED SOIL CLASSIFICATION	MATERIAL DESCRIPTION	Dry Density(pcf)	Moisture Content %	Percent minus 200	Liquid Limit	Plasticity Index	Moisture Content and Atterberg Limits (Plastic Limit — Moisture Content — Liquid Limit; 10 20 30 40 50 60 70 80 90)
0	0					TOPSOIL						
					SM	Silty SAND with gravel and cobbles - loose to medium dense, moist, light brown						
						SILT with sand - medium stiff, dry, light brown and grey, pinholes						
1					SM	Silty SAND with gravel and cobbles - medium dense, moist, light brown to medium brown, pinholes decreasing with depth, sand is fine						
	5											
						Silty SAND with gravel - medium dense, moist, brown, sand is fine						
2												
						Bottom of Test Pit @ 7 Feet						
3												

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SAMPLE TYPE
- GRAB SAMPLE
- 3" O.D. THIN-WALLED HAND SAMPLER

WATER LEVEL
- MEASURED
- ESTIMATED

NOTES:

Figure A-5

DATE	
STARTED:	3/7/13
COMPLETED:	3/7/13
BACKFILLED:	3/7/13

Geotechnical Investigation
CS Mining

Milford, UT — Project Number 01640-001

IGES Rep: NB
Rig Type: Backhoe

TEST PIT NO: **TP-6**
Sheet 1 of 1

LOCATION
Latitude — Longitude — ELEVATION

DEPTH METERS	DEPTH FEET	SAMPLES	WATER LEVEL	GRAPHICAL LOG	UNIFIED SOIL CLASSIFICATION	MATERIAL DESCRIPTION	Dry Density(pcf)	Moisture Content %	Percent minus 200	Liquid Limit	Plasticity Index	Moisture Content and Atterberg Limits (Plastic Limit — Moisture Content — Liquid Limit; 10 20 30 40 50 60 70 80 90)
0	0					TOPSOIL						
					SM	Silty SAND with gravel - medium dense, moist, light brown, sand is fine						
1					ML	SILT with gravel and sand - medium dense, moist to dry, light brown, some cementation, pinholes						
	5					Caliche						
2						Bottom of Test Pit @ 6.5 Feet						
3												

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SAMPLE TYPE
- GRAB SAMPLE
- 3" O.D. THIN-WALLED HAND SAMPLER

WATER LEVEL
- MEASURED
- ESTIMATED

NOTES:

Figure A-6

DATE	
STARTED:	3/7/13
COMPLETED:	3/7/13
BACKFILLED:	3/7/13

Geotechnical Investigation
CS Mining

Milford, UT Project Number 01640-001

IGES Rep: NB
Rig Type: Backhoe

TEST PIT NO: **TP-7**
Sheet 1 of 1

LOCATION
Latitude Longitude ELEVATION

DEPTH METERS	DEPTH FEET	SAMPLES	WATER LEVEL	GRAPHICAL LOG	UNIFIED SOIL CLASSIFICATION	MATERIAL DESCRIPTION	Dry Density(pcf)	Moisture Content %	Percent minus 200	Liquid Limit	Plasticity Index	Moisture Content and Atterberg Limits (Plastic Limit — Moisture Content — Liquid Limit; 10 20 30 40 50 60 70 80 90)
0	0					TOPSOIL						
					SP-SM	Poorly Graded SAND with cobbles and silt - angular blocky granite, cobbles, decomposing granite			7.1	NP	NP	
1						Refusal Bottom of Test Pit @ 3.5 Feet						
	5											
2												
3												

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SAMPLE TYPE
- GRAB SAMPLE
- 3" O.D. THIN-WALLED HAND SAMPLER

WATER LEVEL
- MEASURED
- ESTIMATED

NOTES:

Figure A-7

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			USCS SYMBOL	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS (More than half of material is larger than the #200 sieve)	GRAVELS (More than half of coarse fraction is larger than the #4 sieve)	CLEAN GRAVELS WITH LITTLE OR NO FINES	GW	WELL-GRADED GRAVELS, GRAVEL-SAND MIXTURES WITH LITTLE OR NO FINES
			GP	POORLY-GRADED GRAVELS, GRAVEL-SAND MIXTURES WITH LITTLE OR NO FINES
		GRAVELS WITH OVER 12% FINES	GM	SILTY GRAVELS, GRAVEL-SILT-SAND MIXTURES
			GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES
	SANDS (More than half of coarse fraction is smaller than the #4 sieve)	CLEAN SANDS WITH LITTLE OR NO FINES	SW	WELL-GRADED SANDS, SAND-GRAVEL MIXTURES WITH LITTLE OR NO FINES
			SP	POORLY-GRADED SANDS, SAND-GRAVEL MIXTURES WITH LITTLE OR NO FINES
		SANDS WITH OVER 12% FINES	SM	SILTY SANDS, SAND-GRAVEL-SILT MIXTURES
			SC	CLAYEY SANDS SAND-GRAVEL-CLAY MIXTURES
FINE GRAINED SOILS (More than half of material is smaller than the #200 sieve)	SILTS AND CLAYS (Liquid limit less than 50)		ML	INORGANIC SILTS & VERY FINE SANDS, SILTY OR CLAYEY FINE SANDS, CLAYEY SILTS WITH SLIGHT PLASTICITY
			CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
			OL	ORGANIC SILTS & ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS (Liquid limit greater than 50)		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILT
			CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
			OH	ORGANIC CLAYS & ORGANIC SILTS OF MEDIUM-TO-HIGH PLASTICITY
HIGHLY ORGANIC SOILS			PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

LOG KEY SYMBOLS

- BORING SAMPLE LOCATION
- TEST-PIT SAMPLE LOCATION
- WATER LEVEL (level after completion)
- WATER LEVEL (level where first encountered)

CEMENTATION

DESCRIPTION	DESCRIPTION
WEAKLY	CRUMBLES OR BREAKS WITH HANDLING OR SLIGHT FINGER PRESSURE
MODERATELY	CRUMBLES OR BREAKS WITH CONSIDERABLE FINGER PRESSURE
STRONGLY	WILL NOT CRUMBLE OR BREAK WITH FINGER PRESSURE

OTHER TESTS KEY

C	CONSOLIDATION	SA	SIEVE ANALYSIS
AL	ATTERBURG LIMITS	DS	DIRECT SHEAR
UC	UNCONFINED COMPRESSION	T	TRIAXIAL
S	SOLUBILITY	R	RESISTIVITY
O	ORGANIC CONTENT	RV	R-VALUE
CBR	CALIFORNIA BEARING RATIO	SU	SOLUBLE SULFATES
COMP	MOISTURE/DENSITY RELATIONSHIP	PM	PERMEABILITY
CI	CALIFORNIA IMPACT	-200	% FINER THAN #200
COL	COLLAPSE POTENTIAL	Gs	SPECIFIC GRAVITY
SS	SHRINK SWELL	SL	SWELL LOAD

MODIFIERS

DESCRIPTION	%
TRACE	<5
SOME	5 - 12
WITH	>12

MOISTURE CONTENT

DESCRIPTION	FIELD TEST
DRY	ABSENCE OF MOISTURE, DUSTY, DRY TO THE TOUCH
MOIST	DAMP BUT NO VISIBLE WATER
WET	VISIBLE FREE WATER, USUALLY SOIL BELOW WATER TABLE

STRATIFICATION

DESCRIPTION	THICKNESS	DESCRIPTION	THICKNESS
SEAM	1/16 - 1/2"	OCCASIONAL	ONE OR LESS PER FOOT OF THICKNESS
LAYER	1/2 - 12"	FREQUENT	MORE THAN ONE PER FOOT OF THICKNESS

GENERAL NOTES

1. Lines separating strata on the logs represent approximate boundaries only. Actual transitions may be gradual.
2. No warranty is provided as to the continuity of soil conditions between individual sample locations.
3. Logs represent general soil conditions observed at the point of exploration on the date indicated.
4. In general, Unified Soil Classification designations presented on the logs were evaluated by visual methods only. Therefore, actual designations (based on laboratory tests) may vary.

APPARENT / RELATIVE DENSITY - COARSE-GRAINED SOIL

APPARENT DENSITY	SPT (blows/ft)	MODIFIED CA. SAMPLER (blows/ft)	CALIFORNIA SAMPLER (blows/ft)	RELATIVE DENSITY (%)	FIELD TEST
VERY LOOSE	<4	<4	<5	0 - 15	EASILY PENETRATED WITH 1/2-INCH REINFORCING ROD PUSHED BY HAND
LOOSE	4 - 10	5 - 12	5 - 15	15 - 35	DIFFICULT TO PENETRATE WITH 1/2-INCH REINFORCING ROD PUSHED BY HAND
MEDIUM DENSE	10 - 30	12 - 35	15 - 40	35 - 65	EASILY PENETRATED A FOOT WITH 1/2-INCH REINFORCING ROD DRIVEN WITH 5-LB HAMMER
DENSE	30 - 50	35 - 60	40 - 70	65 - 85	DIFFICULT TO PENETRATED A FOOT WITH 1/2-INCH REINFORCING ROD DRIVEN WITH 5-LB HAMMER
VERY DENSE	>50	>60	>70	85 - 100	PENETRATED ONLY A FEW INCHES WITH 1/2-INCH REINFORCING ROD DRIVEN WITH 5-LB HAMMER

CONSISTENCY - FINE-GRAINED SOIL

CONSISTENCY	SPT (blows/ft)	TORVANE UNTRAINED SHEAR STRENGTH (tsf)	POCKET PENETROMETER UNCONFINED COMPRESSIVE STRENGTH (tsf)	FIELD TEST
VERY SOFT	<2	<0.125	<0.25	EASILY PENETRATED SEVERAL INCHES BY THUMB. EXUDES BETWEEN THUMB AND FINGERS WHEN SQUEEZED BY HAND.
SOFT	2 - 4	0.125 - 0.25	0.25 - 0.5	EASILY PENETRATED ONE INCH BY THUMB. MOLDED BY LIGHT FINGER PRESSURE.
MEDIUM STIFF	4 - 8	0.25 - 0.5	0.5 - 1.0	PENETRATED OVER 1/2 INCH BY THUMB WITH MODERATE EFFORT. MOLDED BY STRONG FINGER PRESSURE.
STIFF	8 - 15	0.5 - 1.0	1.0 - 2.0	INDENTED ABOUT 1/2 INCH BY THUMB BUT PENETRATED ONLY WITH GREAT EFFORT.
VERY STIFF	15 - 30	1.0 - 2.0	2.0 - 4.0	READILY INDENTED BY THUMBNAIL
HARD	>30	>2.0	>4.0	INDENTED WITH DIFFICULTY BY THUMBNAIL

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Project Number 00123-058

Plate

A-10

APPENDIX B

Liquid Limit, Plastic Limit, and Plasticity Index of Soils

(ASTM D4318)

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Project: CS Mining Existing Facility Expansion
No: 01640-001 (II)
Location: Milford, UT
Date: 3/13/2013
By: DKS

Boring No.: TP-3
Sample: Combined Samples
Depth: 1-3'
Description: Brown silty sand

Preparation method: Air Dry
Liquid Limit: Could not be determined (N.P.)

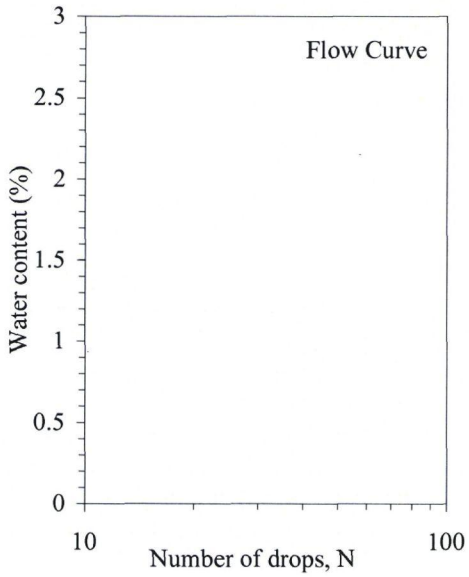
Plastic Limit

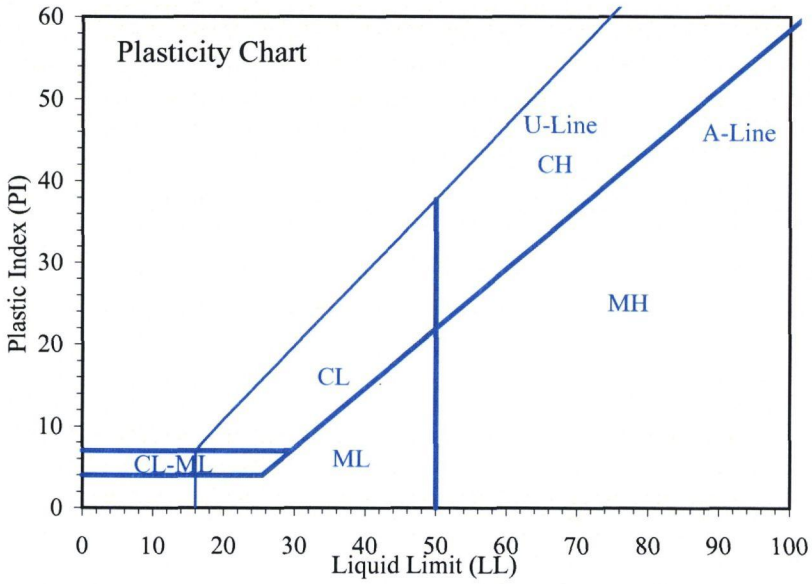
Determination No						
Wet Soil + Tare (g)						
Dry Soil + Tare (g)		Difficult to thread.				
Water Loss (g)						
Tare (g)						
Dry Soil (g)						
Water Content, w (%)						

Liquid Limit: Could not be determined (N.P.)

Determination No						
Number of Drops, N						
Wet Soil + Tare (g)	Unable to obtain an adequate blow count.					
Dry Soil + Tare (g)						
Water Loss (g)						
Tare (g)						
Dry Soil (g)						
Water Content, w (%)						
One-Point LL (%)						

Liquid Limit, LL (%)	**Nonplastic (N.P.)**
Plastic Limit, PL (%)	
Plasticity Index, PI (%)	





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Liquid Limit, Plastic Limit, and Plasticity Index of Soils

(ASTM D4318)

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Project: CS Mining Existing Facility Expansion
No: 01640-001 (II)
Location: Milford, UT
Date: 3/19/2013
By: DKS

Boring No.: TP-4
Sample:
Depth: 3-5'
Description: Brown lean clay

Preparation method: Air Dry
Liquid limit test method: Multipoint

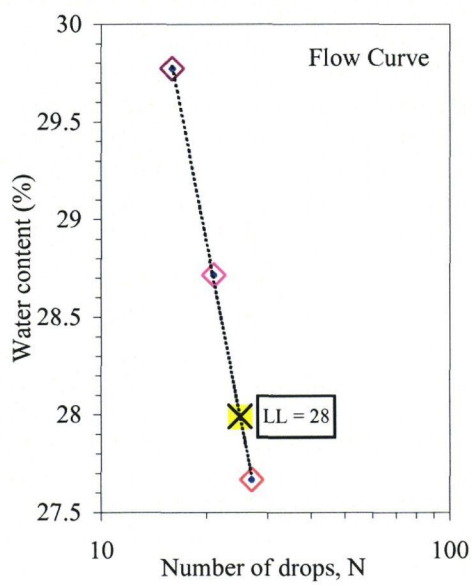
Plastic Limit

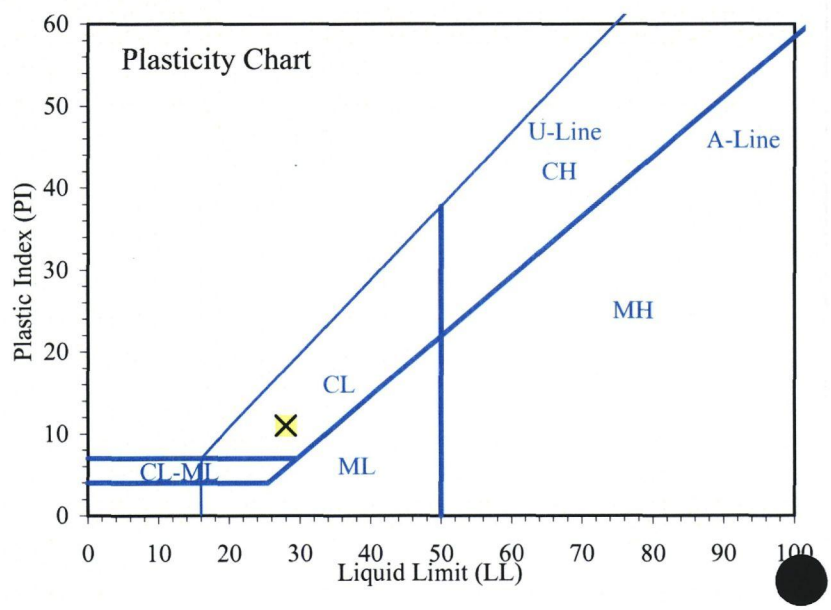
Determination No	1	2				
Wet Soil + Tare (g)	34.48	35.42				
Dry Soil + Tare (g)	32.69	33.50				
Water Loss (g)	1.79	1.92				
Tare (g)	21.88	21.97				
Dry Soil (g)	10.81	11.53				
Water Content, w (%)	16.56	16.65				

Liquid Limit

Determination No	1	2	3			
Number of Drops, N	27	21	16			
Wet Soil + Tare (g)	36.86	35.84	37.70			
Dry Soil + Tare (g)	33.62	32.73	34.02			
Water Loss (g)	3.24	3.11	3.68			
Tare (g)	21.91	21.90	21.66			
Dry Soil (g)	11.71	10.83	12.36			
Water Content, w (%)	27.67	28.72	29.77			
One-Point LL (%)	28	28				

Liquid Limit, LL (%)	**28**
Plastic Limit, PL (%)	**17**
Plasticity Index, PI (%)	**11**





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Liquid Limit, Plastic Limit, and Plasticity Index of Soils

(ASTM D4318)

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Project: CS Mining Existing Facility Expansion
No: 01640-001 (II)
Location: Milford, UT
Date: 3/19/2013
By: DKS

Boring No.: TP-4
Sample:
Depth: 5-6'
Description: Brown lean clay

Preparation method: Air Dry
Liquid limit test method: Multipoint

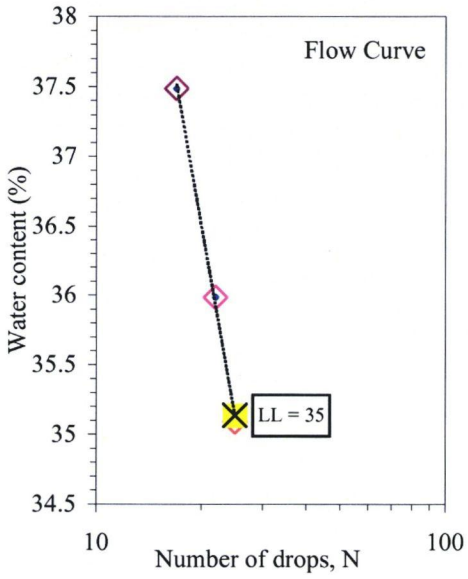
Plastic Limit

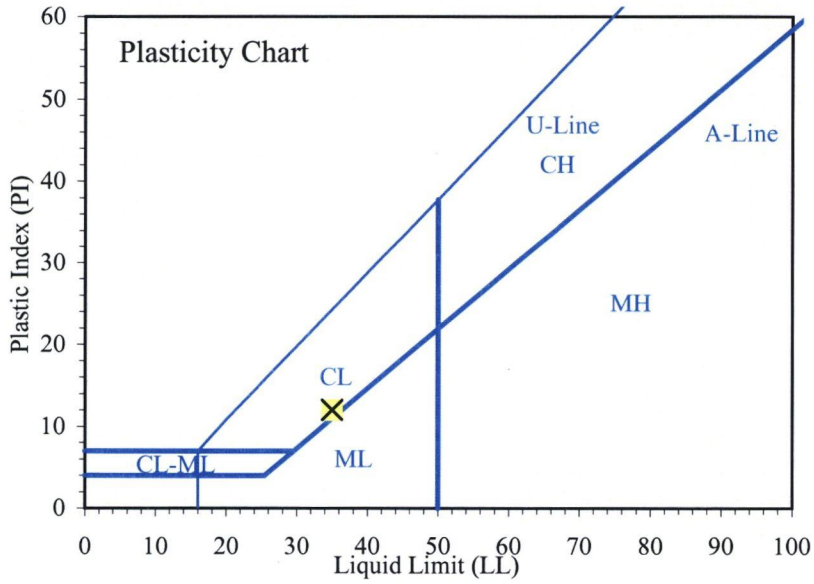
Determination No	1	2				
Wet Soil + Tare (g)	37.58	38.16				
Dry Soil + Tare (g)	34.61	35.05				
Water Loss (g)	2.97	3.11				
Tare (g)	21.55	21.47				
Dry Soil (g)	13.06	13.58				
Water Content, w (%)	22.74	22.90				

Liquid Limit

Determination No	1	2	3			
Number of Drops, N	25	22	17			
Wet Soil + Tare (g)	34.79	34.76	35.72			
Dry Soil + Tare (g)	31.40	31.28	31.90			
Water Loss (g)	3.39	3.48	3.82			
Tare (g)	21.74	21.61	21.71			
Dry Soil (g)	9.66	9.67	10.19			
Water Content, w (%)	35.09	35.99	37.49			
One-Point LL (%)	35	35				

Liquid Limit, LL (%)	**35**
Plastic Limit, PL (%)	**23**
Plasticity Index, PI (%)	**12**





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Liquid Limit, Plastic Limit, and Plasticity Index of Soils

(ASTM D4318)

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Project: CS Mining Existing Facility Expansion
No: 01640-001 (II)
Location: Milford, UT
Date: 3/19/2013
By: DKS

Boring No.: TP-5
Sample: Combined Samples
Depth: 3-4' & 6'
Description: Brown silty sand

Preparation method: Air Dry
Liquid Limit: Could not be determined (N.P.)

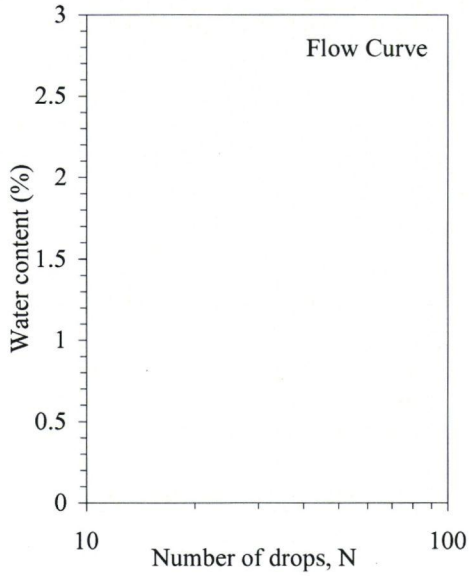
Plastic Limit

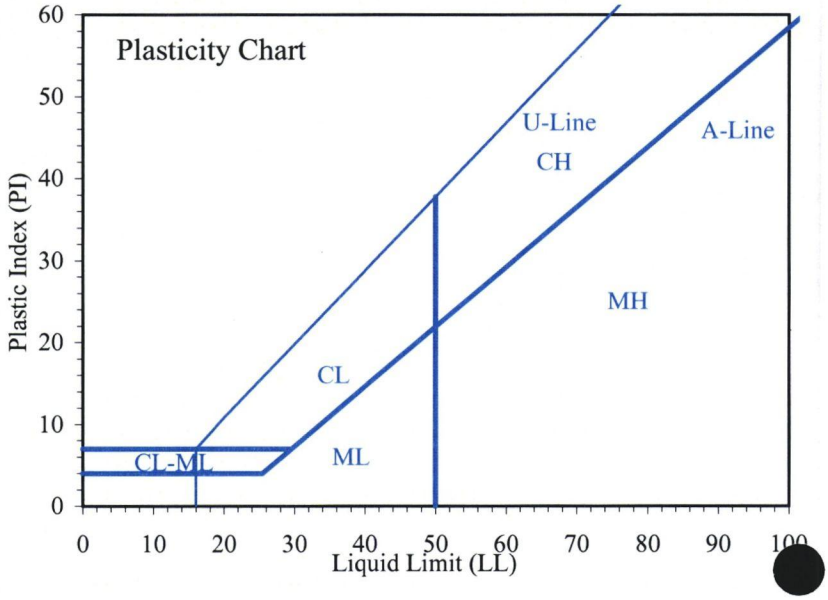
Determination No						
Wet Soil + Tare (g)						
Dry Soil + Tare (g)		Difficult to thread.				
Water Loss (g)						
Tare (g)						
Dry Soil (g)						
Water Content, w (%)						

Liquid Limit: Could not be determined (N.P.)

Determination No						
Number of Drops, N						
Wet Soil + Tare (g)						
Dry Soil + Tare (g)	Unable to obtain an adequate blow count.					
Water Loss (g)						
Tare (g)						
Dry Soil (g)						
Water Content, w (%)						
One-Point LL (%)						

Liquid Limit, LL (%)	**Nonplastic (N.P.)**
Plastic Limit, PL (%)	
Plasticity Index, PI (%)	





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Liquid Limit, Plastic Limit, and Plasticity Index of Soils

(ASTM D4318)

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Project: CS Mining Existing Facility Expansion
No: 01640-001 (II)
Location: Milford, UT
Date: 3/13/2013
By: DKS

Boring No.: TP-6
Sample: Combined Samples
Depth: 2-3' & 5-6'
Description: Brown silt

Preparation method: Air Dry
Liquid Limit: Could not be determined (N.P.)

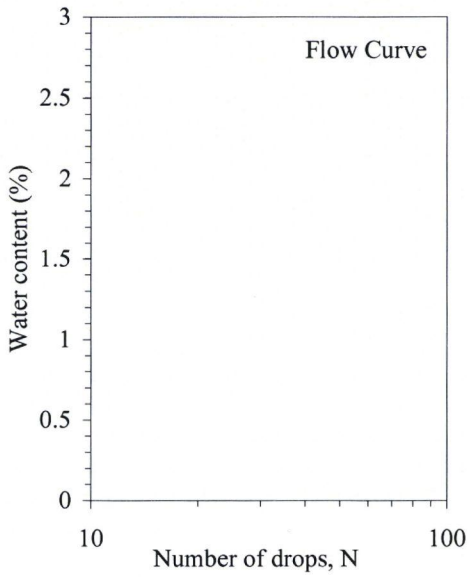
Plastic Limit

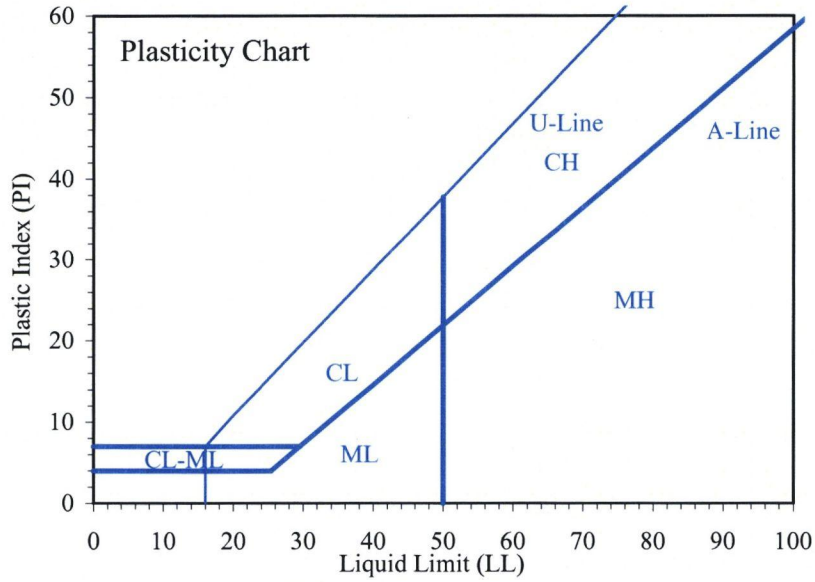
Determination No						
Wet Soil + Tare (g)						
Dry Soil + Tare (g)		Difficult to thread.				
Water Loss (g)						
Tare (g)						
Dry Soil (g)						
Water Content, w (%)						

Liquid Limit: Could not be determined (N.P.)

Determination No						
Number of Drops, N						
Wet Soil + Tare (g)	Unable to obtain an adequate blow count.					
Dry Soil + Tare (g)						
Water Loss (g)						
Tare (g)						
Dry Soil (g)						
Water Content, w (%)						
One-Point LL (%)						

Liquid Limit, LL (%)	**Nonplastic (N.P.)**
Plastic Limit, PL (%)	
Plasticity Index, PI (%)	





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Liquid Limit, Plastic Limit, and Plasticity Index of Soils

(ASTM D4318)

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Project: CS Mining Existing Facility Expansion
No: 01640-001 (II)
Location: Milford, UT
Date: 3/19/2013
By: DKS

Boring No.: TP-7
Sample:
Depth: 2-3'
Description: Brown silty sand

Preparation method: Air Dry
Liquid Limit: Could not be determined (N.P.)

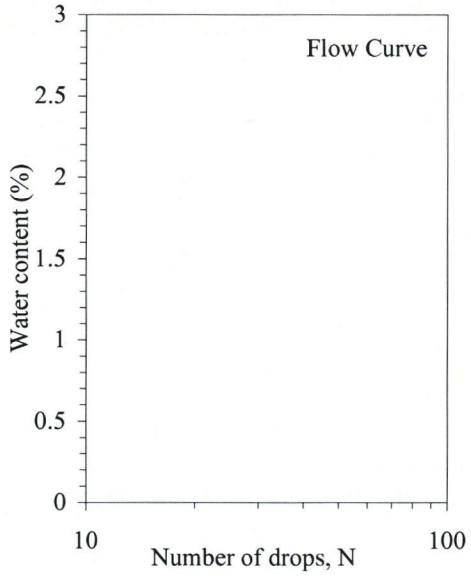
Plastic Limit

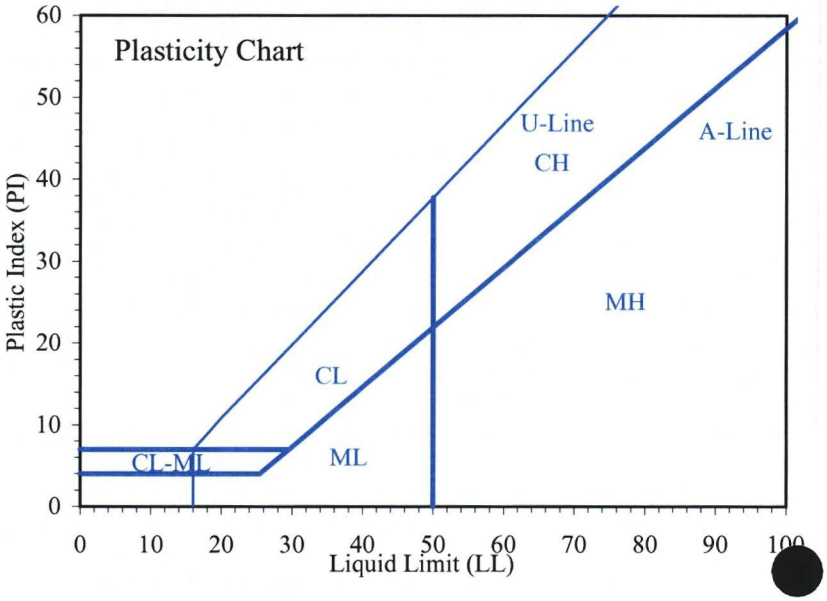
Determination No						
Wet Soil + Tare (g)						
Dry Soil + Tare (g)		Difficult to thread.				
Water Loss (g)						
Tare (g)						
Dry Soil (g)						
Water Content, w (%)						

Liquid Limit: Could not be determined (N.P.)

Determination No						
Number of Drops, N						
Wet Soil + Tare (g)						
Dry Soil + Tare (g)	Unable to obtain an adequate blow count.					
Water Loss (g)						
Tare (g)						
Dry Soil (g)						
Water Content, w (%)						
One-Point LL (%)						

Liquid Limit, LL (%)	**Nonplastic (N.P.)**
Plastic Limit, PL (%)	
Plasticity Index, PI (%)	





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Liquid Limit, Plastic Limit, and Plasticity Index of Soils

(ASTM D4318)

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Project: CS Mining Existing Facility Expansion
No: 01640-001 (II)
Location: Milford, UT
Date: 3/19/2013
By: DKS

Boring No.: TP-8
Sample:
Depth: 3-4'
Description: Brown silty sand

Preparation method: Air Dry
Liquid Limit: Could not be determined (N.P.)

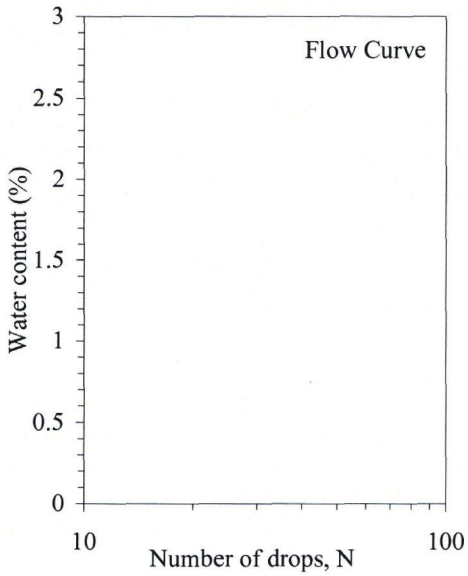
Plastic Limit

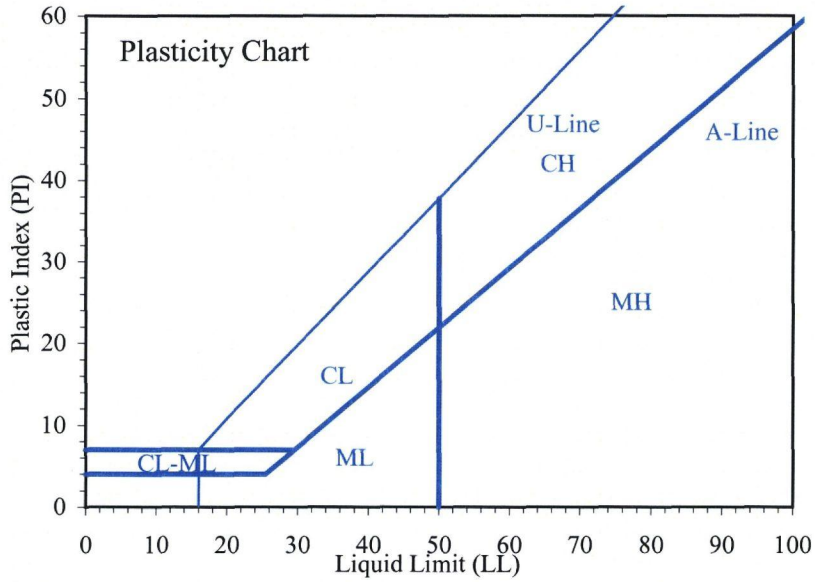
Determination No						
Wet Soil + Tare (g)						
Dry Soil + Tare (g)		Difficult to thread.				
Water Loss (g)						
Tare (g)						
Dry Soil (g)						
Water Content, w (%)						

Liquid Limit: Could not be determined (N.P.)

Determination No						
Number of Drops, N						
Wet Soil + Tare (g)						
Dry Soil + Tare (g)	Unable to obtain an adequate blow count.					
Water Loss (g)						
Tare (g)						
Dry Soil (g)						
Water Content, w (%)						
One-Point LL (%)						

Liquid Limit, LL (%)	**Nonplastic (N.P.)**
Plastic Limit, PL (%)	
Plasticity Index, PI (%)	





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Liquid Limit, Plastic Limit, and Plasticity Index of Soils

(ASTM D4318)

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Project: CS Mining Existing Facility Expansion
No: 01640-001 (II)
Location: Milford, UT
Date: 3/19/2013
By: DKS

Boring No.: TP-9
Sample:
Depth: 3-4'
Description: Brown silty sand

Preparation method: Air Dry
Liquid Limit: Could not be determined (N.P.)

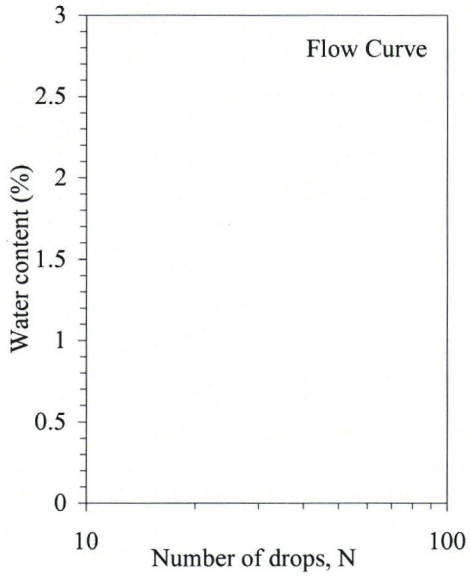
Plastic Limit

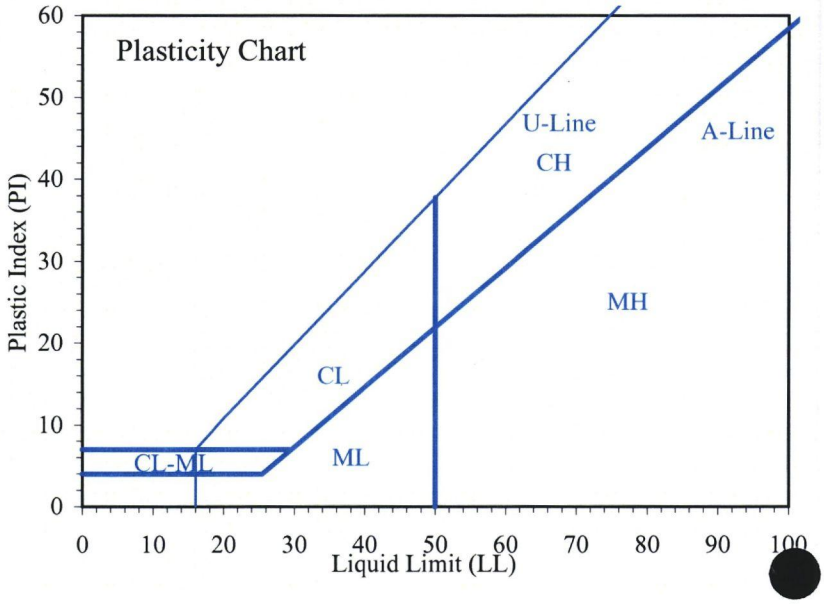
Determination No						
Wet Soil + Tare (g)						
Dry Soil + Tare (g)		Difficult to thread.				
Water Loss (g)						
Tare (g)						
Dry Soil (g)						
Water Content, w (%)						

Liquid Limit: Could not be determined (N.P.)

Determination No						
Number of Drops, N						
Wet Soil + Tare (g)						
Dry Soil + Tare (g)	Unable to obtain an adequate blow count.					
Water Loss (g)						
Tare (g)						
Dry Soil (g)						
Water Content, w (%)						
One-Point LL (%)						

Liquid Limit, LL (%)	**Nonplastic (N.P.)**
Plastic Limit, PL (%)	
Plasticity Index, PI (%)	





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Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

(ASTM D6913)

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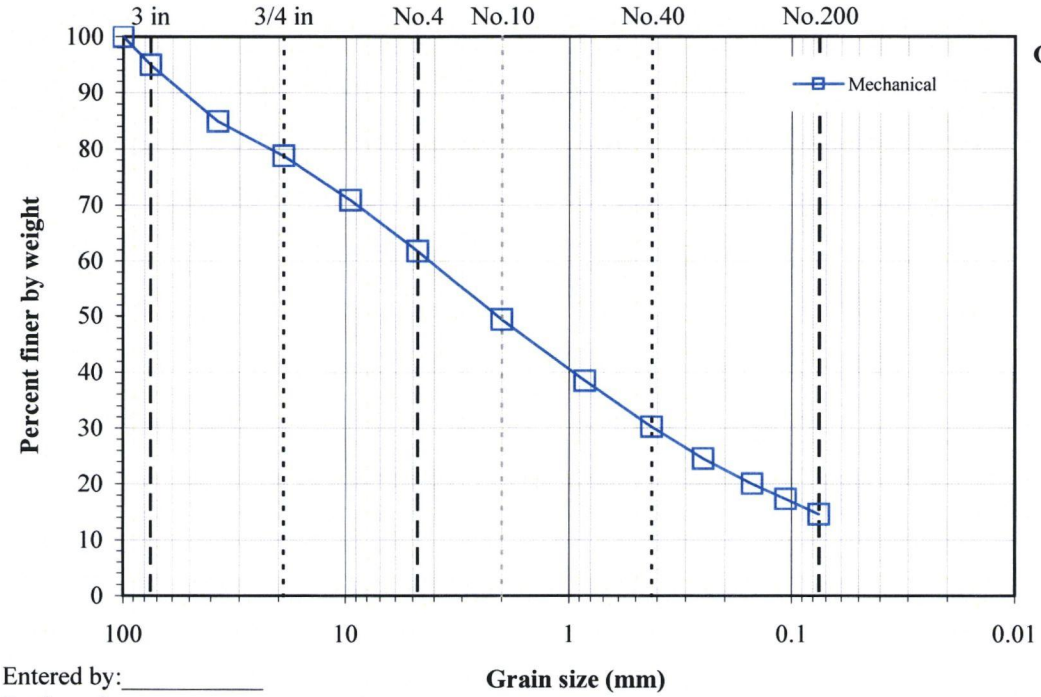
Project: CS Mining Existing Facility Expansion
No: 01640-001 (II)
Location: Milford, UT
Date: 3/13/2013
By: BRR

Boring No.: TP-3
Sample: Combined Samples
Depth: 1-3'
Description: Brown silty sand with gravel

Split:	Yes	
Split sieve:	3/4"	
	Moist	Dry
Total sample wt. (g):	51492.80	49124.9
+3/4" Coarse fraction (g):	10584.6	10420.4
-3/4" Split fraction (g):	1428.46	1351.51
Split fraction:	0.788	

Water content data	C.F.(+3/4")	S.F.(-3/4")
Moist soil + tare (g):	1382.89	1837.27
Dry soil + tare (g):	1364.78	1760.32
Tare (g):	215.39	408.81
Water content (%):	1.6	5.7

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer	
8"	-	200	-	
6"	-	150	-	
4"	-	100	100.0	
3"	2486.62	75	94.9	
1.5"	7432.20	37.5	84.9	
3/4"	10420.41	19	78.8	←Split
3/8"	135.15	9.5	70.9	
No.4	292.17	4.75	61.8	
No.10	504.60	2	49.4	
No.20	692.94	0.85	38.4	
No.40	832.15	0.425	30.3	
No.60	930.44	0.25	24.5	
No.100	1008.26	0.15	20.0	
No.140	1054.23	0.106	17.3	
No.200	1101.47	0.075	14.6	



Gravel (%): 38.2
Sand (%): 47.2
Fines (%): 14.6

Entered by:_____
Reviewed:_____

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Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

(ASTM D6913)

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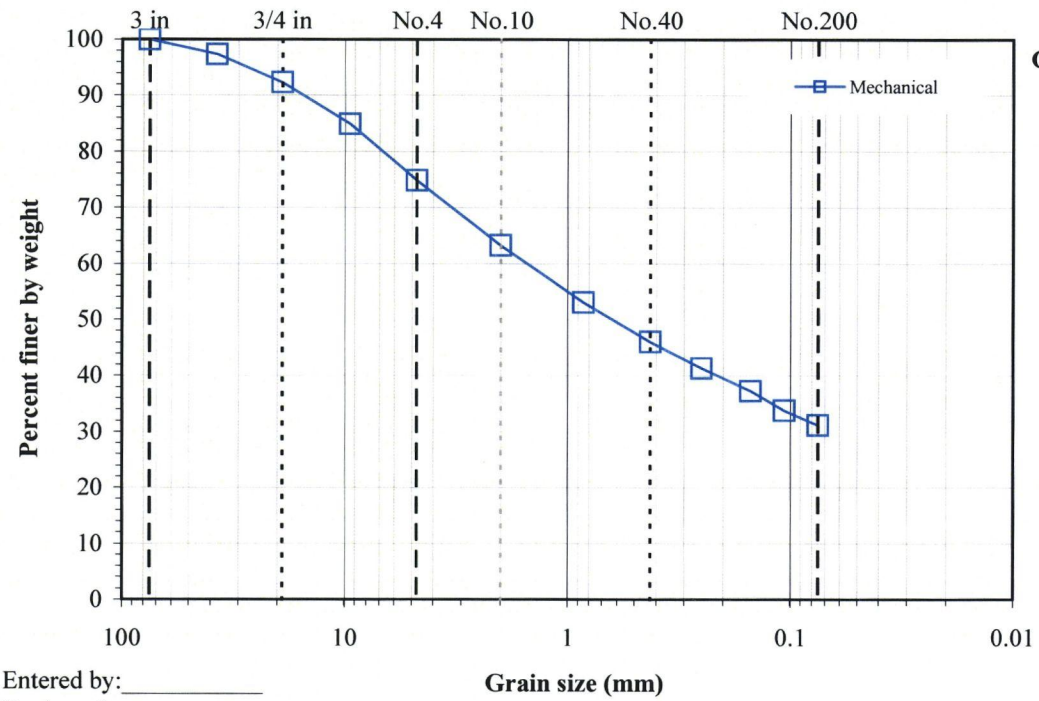
Project: CS Mining Existing Facility Expansion
No: 01640-001 (II)
Location: Milford, UT
Date: 3/19/2013
By: BRR

Boring No.: TP-4
Sample:
Depth: 3-5'
Description: Brown clayey sand with gravel

Split:	Yes	
Split sieve:	3/4"	
	Moist	Dry
Total sample wt. (g):	24749.68	23534.9
+3/4" Coarse fraction (g):	1814.48	1790.9
-3/4" Split fraction (g):	1493.41	1415.85
Split fraction:	0.924	

Water content data	C.F.(+3/4")	S.F.(-3/4")
Moist soil + tare (g):	2026.03	1901.93
Dry soil + tare (g):	2002.42	1824.37
Tare (g):	211.56	408.52
Water content (%):	1.3	5.5

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer	
8"	-	200	-	
6"	-	150	-	
4"	-	100	-	
3"	-	75	100.0	
1.5"	619.31	37.5	97.4	
3/4"	1790.87	19	92.4	←Split
3/8"	114.98	9.5	84.9	
No.4	268.60	4.75	74.9	
No.10	446.53	2	63.3	
No.20	603.06	0.85	53.0	
No.40	709.62	0.425	46.1	
No.60	782.82	0.25	41.3	
No.100	844.50	0.15	37.3	
No.140	897.82	0.106	33.8	
No.200	937.22	0.075	31.2	



Gravel (%): 25.1
Sand (%): 43.6
Fines (%): 31.2

Entered by:_____
Reviewed:_____

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Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

(ASTM D6913)

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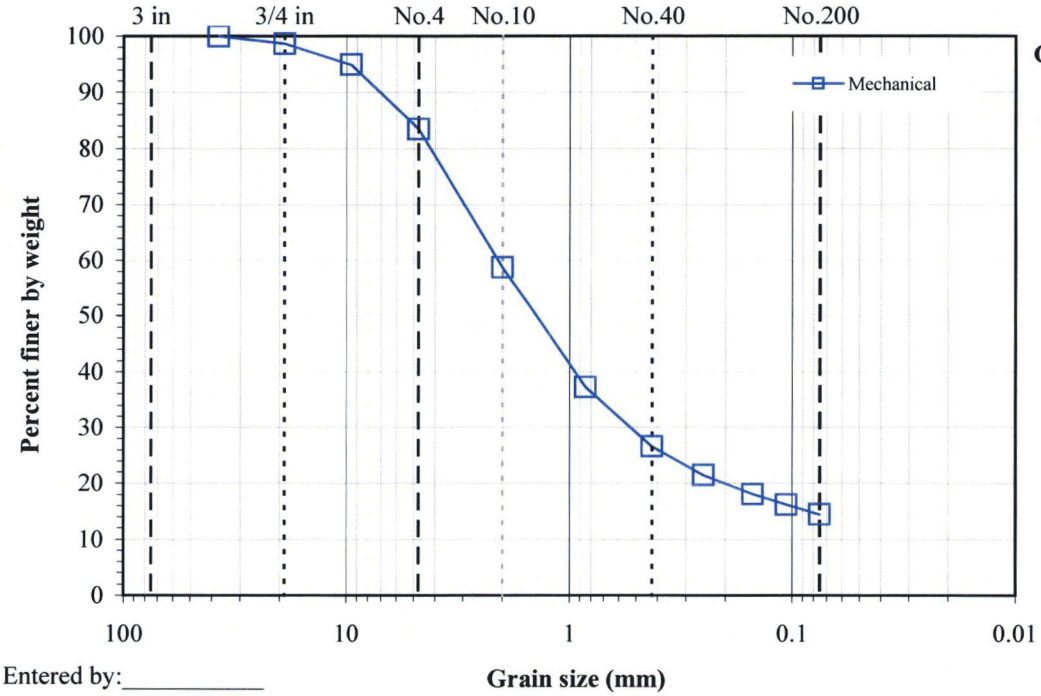
Project: CS Mining Existing Facility Expansion
No: 01640-001 (II)
Location: Milford, UT
Date: 3/19/2013
By: BRR

Boring No.: TP-4
Sample:
Depth: 5-6'
Description: Light brown clayey sand with gravel

Split:	Yes	
Split sieve:	3/8"	
	Moist	Dry
Total sample wt. (g):	24740.03	23683.0
+3/8" Coarse fraction (g):	1200.53	1181.0
-3/8" Split fraction (g):	1333.15	1274.39
Split fraction:	0.950	

Water content data	C.F.(+3/8")	S.F.(-3/8")
Moist soil + tare (g):	1424.10	1643.73
Dry soil + tare (g):	1404.61	1584.97
Tare (g):	223.56	310.58
Water content (%):	1.7	4.6

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer	
8"	-	200	-	
6"	-	150	-	
4"	-	100	-	
3"	-	75	-	
1.5"	-	37.5	100.0	
3/4"	310.72	19	98.7	
3/8"	1181.04	9.5	95.0	←Split
No.4	155.30	4.75	83.4	
No.10	486.00	2	58.8	
No.20	774.33	0.85	37.3	
No.40	917.02	0.425	26.6	
No.60	986.29	0.25	21.5	
No.100	1032.02	0.15	18.1	
No.140	1057.20	0.106	16.2	
No.200	1080.10	0.075	14.5	



Gravel (%): 16.6
Sand (%): 68.9
Fines (%): 14.5

Entered by:_____
Reviewed:_____

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Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

(ASTM D6913)

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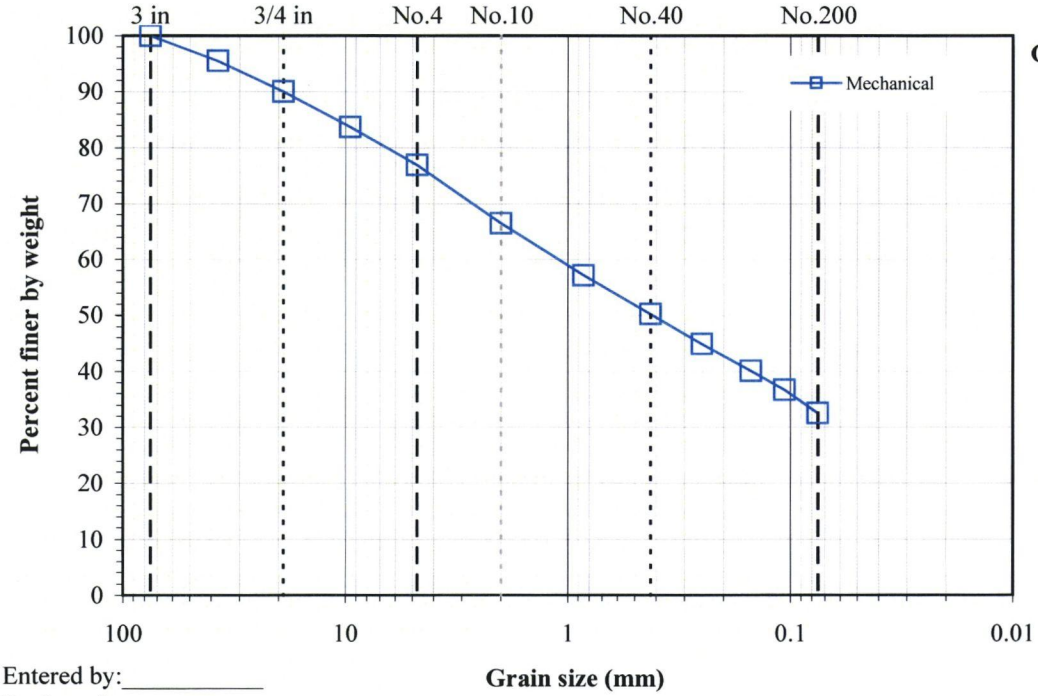
Project: CS Mining Existing Facility Expansion
No: 01640-001 (II)
Location: Milford, UT
Date: 3/19/2013
By: BRR

Boring No.: TP-5
Sample: Combined Samples
Depth: 3-4' & 6'
Description: Brown silty sand with gravel

Split:	Yes	
Split sieve:	3/4"	
	Moist	Dry
Total sample wt. (g):	29937.60	27914.3
+3/4" Coarse fraction (g):	2835.1	2770.24
-3/4" Split fraction (g):	1462.75	1357.05
Split fraction:	0.901	

Water content data	C.F.(+3/4")	S.F.(-3/4")
Moist soil + tare (g):	1162.34	1872.56
Dry soil + tare (g):	1145.97	1766.86
Tare (g):	446.79	409.81
Water content (%):	2.3	7.8

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer	
8"	-	200	-	
6"	-	150	-	
4"	-	100	-	
3"	-	75	100.0	
1.5"	1238.99	37.5	95.6	
3/4"	2770.24	19	90.1	←Split
3/8"	96.87	9.5	83.6	
No.4	198.12	4.75	76.9	
No.10	356.19	2	66.4	
No.20	495.76	0.85	57.2	
No.40	598.96	0.425	50.3	
No.60	680.14	0.25	44.9	
No.100	753.83	0.15	40.0	
No.140	804.63	0.106	36.7	
No.200	866.29	0.075	32.6	



Gravel (%): 23.1
Sand (%): 44.4
Fines (%): 32.6

Entered by:_____
Reviewed:_____

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Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

(ASTM D6913)

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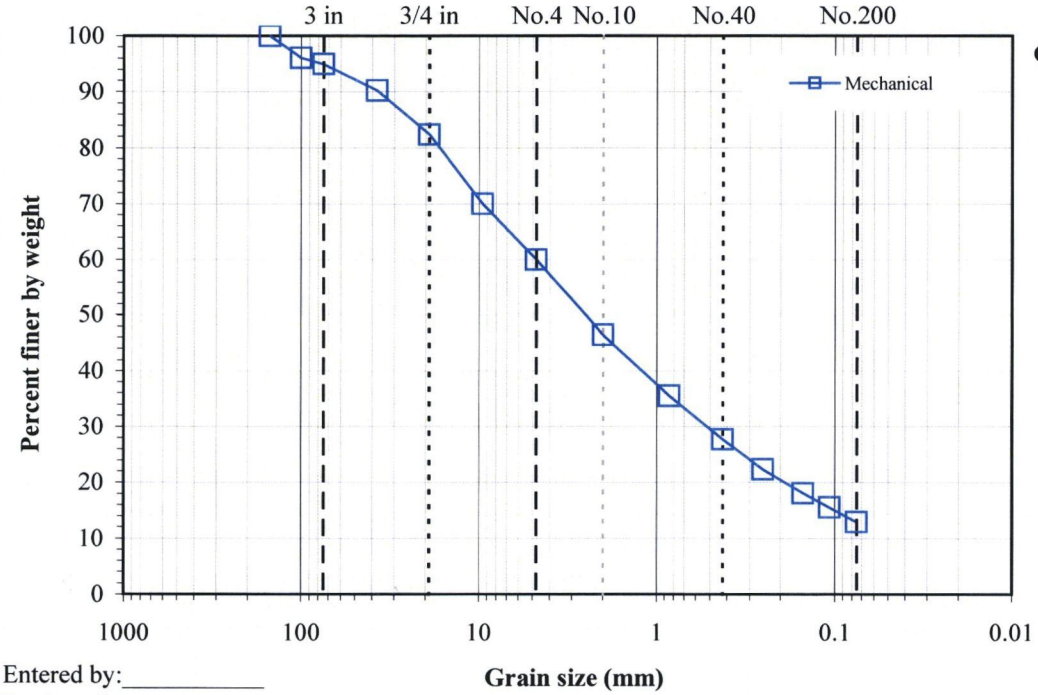
Project: CS Mining Existing Facility Expansion
No: 01640-001 (II)
Location: Milford, UT
Date: 3/12/2013
By: BRR

Boring No.: TP-6
Sample: Combined Samples
Depth: 2-3' & 5-6'
Description: Brown silty sand with gravel

Split:	Yes	
Split sieve:	3/4"	
	Moist	Dry
Total sample wt. (g):	54142.50	51306.5
+3/4" Coarse fraction (g):	9270.1	9041.3
-3/4" Split fraction (g):	1411.32	1329.32
Split fraction:	0.824	

Water content data	C.F.(+3/4")	S.F.(-3/4")
Moist soil + tare (g):	1608.92	1821.81
Dry soil + tare (g):	1579.30	1739.81
Tare (g):	408.93	410.49
Water content (%):	2.5	6.2

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer	
8"	-	200	-	
6"	-	150	100.0	
4"	2001.06	100	96.1	
3"	2580.78	75	95.0	
1.5"	5025.03	37.5	90.2	
3/4"	9041.28	19	82.4	←Split
3/8"	200.51	9.5	70.0	
No.4	360.09	4.75	60.1	
No.10	579.84	2	46.4	
No.20	757.12	0.85	35.5	
No.40	882.23	0.425	27.7	
No.60	969.19	0.25	22.3	
No.100	1036.91	0.15	18.1	
No.140	1078.58	0.106	15.5	
No.200	1120.82	0.075	12.9	



Gravel (%): 39.9
Sand (%): 47.1
Fines (%): 12.9

Entered by:_____
Reviewed:_____

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Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

(ASTM D6913)

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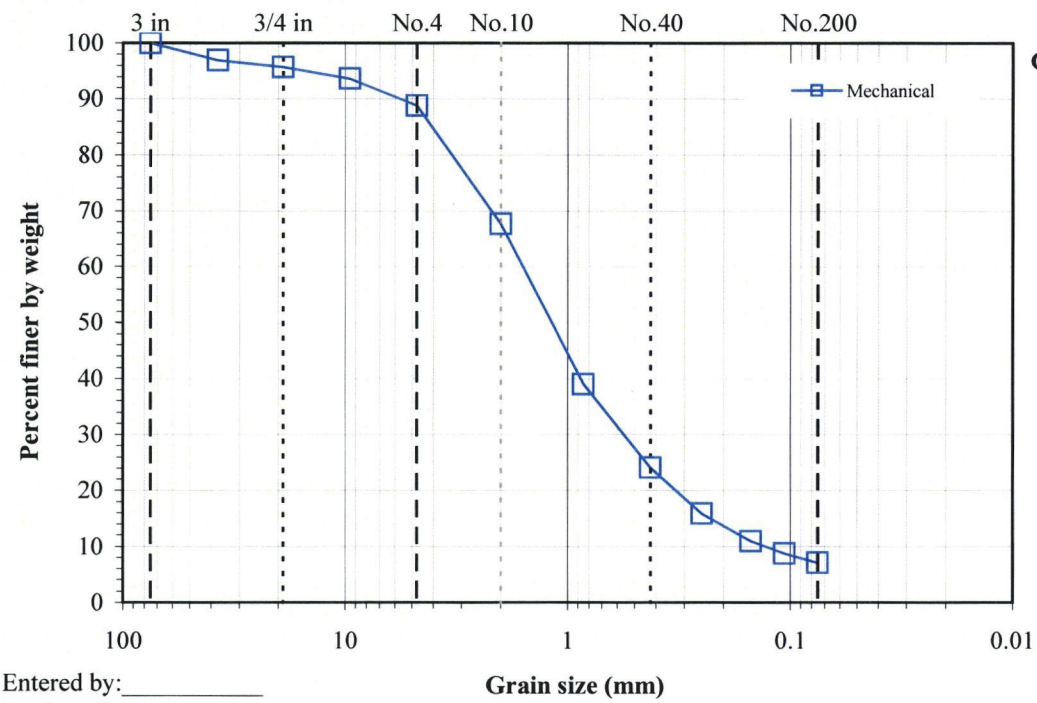
Project: CS Mining Existing Facility Expansion
No: 01640-001 (II)
Location: Milford, UT
Date: 3/19/2013
By: BRR

Boring No.: TP-7
Sample:
Depth: 2-3'
Description: Brown sand with silt

Split:	Yes	
Split sieve:	3/4"	
	Moist	Dry
Total sample wt. (g):	27690.11	26689.7
+3/4" Coarse fraction (g):	1167.91	1148.9
-3/4" Split fraction (g):	1497.66	1442.24
Split fraction:	0.957	

Water content data	C.F.(+3/4")	S.F.(-3/4")
Moist soil + tare (g):	1387.12	1813.48
Dry soil + tare (g):	1368.10	1758.06
Tare (g):	219.18	315.82
Water content (%):	1.7	3.8

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer	
8"	-	200	-	
6"	-	150	-	
4"	-	100	-	
3"	-	75	100.0	
1.5"	822.88	37.5	96.9	
3/4"	1148.89	19	95.7	←Split
3/8"	31.41	9.5	93.6	
No.4	102.75	4.75	88.9	
No.10	422.36	2	67.7	
No.20	854.17	0.85	39.0	
No.40	1078.68	0.425	24.1	
No.60	1203.08	0.25	15.9	
No.100	1277.34	0.15	10.9	
No.140	1310.37	0.106	8.7	
No.200	1334.73	0.075	7.1	



Gravel (%): 11.1
Sand (%): 81.7
Fines (%): 7.1

Entered by:_____
Reviewed:_____

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Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

(ASTM D6913)

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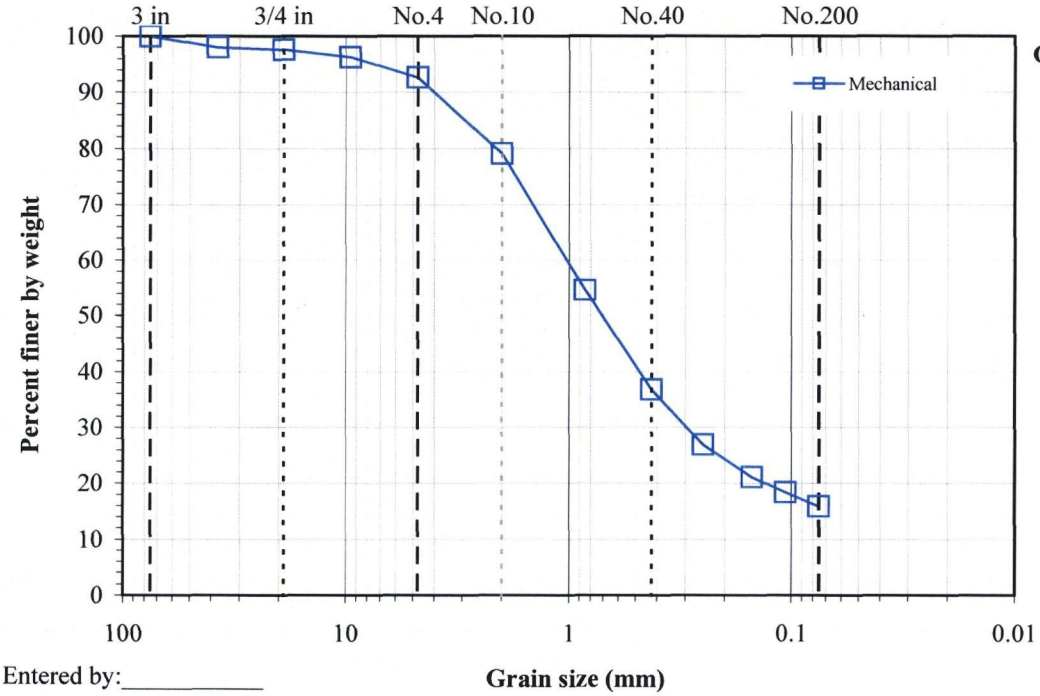
Project: CS Mining Existing Facility Expansion
No: 01640-001 (II)
Location: Milford, UT
Date: 3/19/2013
By: BRR

Boring No.: TP-8
Sample:
Depth: 3-4'
Description: Brown silty sand

Split:	Yes	
Split sieve:	3/8"	
	Moist	Dry
Total sample wt. (g):	25314.71	24389.2
+3/8" Coarse fraction (g):	914.6	904.1
-3/8" Split fraction (g):	1417.82	1364.65
Split fraction:	0.963	

Water content data	C.F.(+3/8")	S.F.(-3/8")
Moist soil + tare (g):	1144.10	1826.72
Dry soil + tare (g):	1133.50	1773.55
Tare (g):	221.95	408.90
Water content (%):	1.2	3.9

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer	
8"	-	200	-	
6"	-	150	-	
4"	-	100	-	
3"	-	75	100.0	
1.5"	483.63	37.5	98.0	
3/4"	585.78	19	97.6	
3/8"	904.09	9.5	96.3	←Split
No.4	51.72	4.75	92.6	
No.10	243.89	2	79.1	
No.20	589.92	0.85	54.7	
No.40	843.07	0.425	36.8	
No.60	983.22	0.25	26.9	
No.100	1065.02	0.15	21.1	
No.140	1103.94	0.106	18.4	
No.200	1140.13	0.075	15.8	



Gravel (%): 7.4
Sand (%): 76.8
Fines (%): 15.8

Entered by:_____
Reviewed:_____

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Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

(ASTM D6913)

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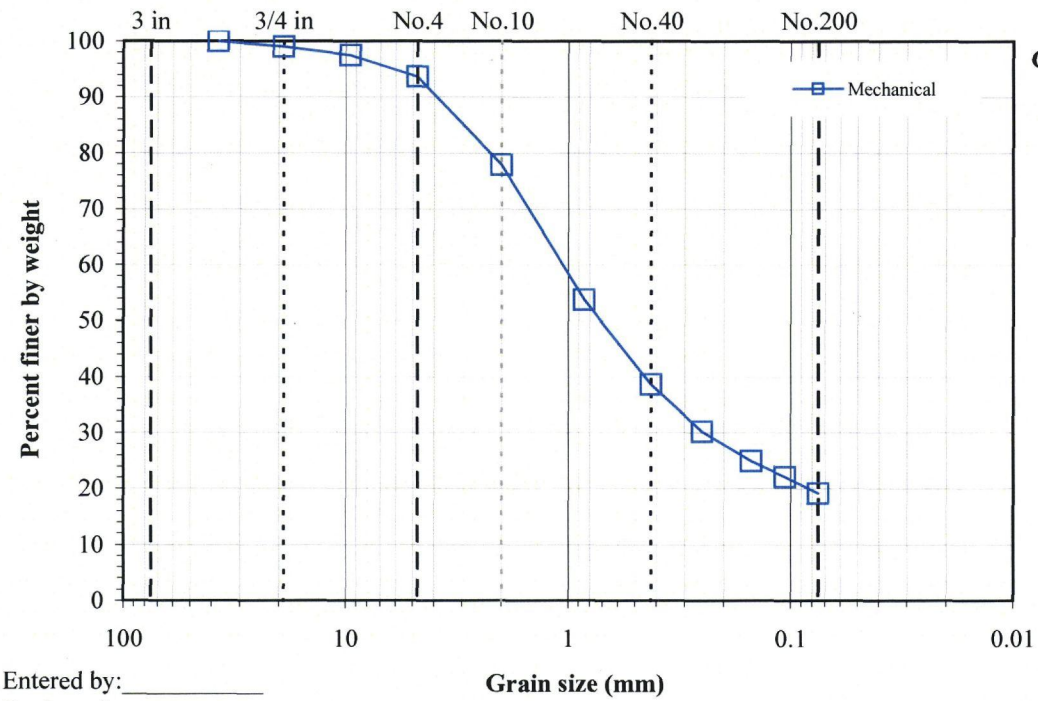
Project: CS Mining Existing Facility Expansion
No: 01640-001 (II)
Location: Milford, UT
Date: 3/19/2013
By: BRR

Boring No.: TP-9
Sample:
Depth: 3-4'
Description: Brown silty sand

Split:	Yes	
Split sieve:	3/8"	
	Moist	Dry
Total sample wt. (g):	23782.06	22671.6
+3/8" Coarse fraction (g):	573.16	564.2
-3/8" Split fraction (g):	1068.84	1018.11
Split fraction:	0.975	

Water content data	C.F.(+3/8")	S.F.(-3/8")
Moist soil + tare (g):	701.07	1477.80
Dry soil + tare (g):	692.15	1427.07
Tare (g):	127.89	408.96
Water content (%):	1.6	5.0

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer	
8"	-	200	-	
6"	-	150	-	
4"	-	100	-	
3"	-	75	-	
1.5"	-	37.5	100.0	
3/4"	217.12	19	99.0	
3/8"	564.24	9.5	97.5	←Split
No.4	40.49	4.75	93.6	
No.10	204.90	2	77.9	
No.20	456.22	0.85	53.8	
No.40	614.42	0.425	38.7	
No.60	701.93	0.25	30.3	
No.100	757.61	0.15	24.9	
No.140	787.21	0.106	22.1	
No.200	817.63	0.075	19.2	



Gravel (%): 6.4
Sand (%): 74.4
Fines (%): 19.2

Entered by:_____
Reviewed:_____

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Laboratory Compaction Characteristics of Soil

(ASTM D698 / D1557)

IGES

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Project: CS Mining Existing Facility Expansion
No: 01640-001 (II)
Location: Milford, UT
Date: 3/13/2013
By: BRR

Boring No.: TP-3
Sample: Combined Samples
Depth: 1-3'
Sample Description: Brown silty sand with gravel
Engineering Classification: Not requested
As-received water content (%): Not requested

Method: ASTM D698 C
Mold Id. Inc 7
Mold volume (ft^3): 0.0752

Preparation method: Moist
Rammer: Mechanical-sector face
Rock Correction: Yes * See results below
Percent fraction retained, Pc (%) 21.2
Percent fraction passing, Pf (%) 78.8

Optimum water content (%): 10.3
Maximum dry unit weight (pcf): 127.5

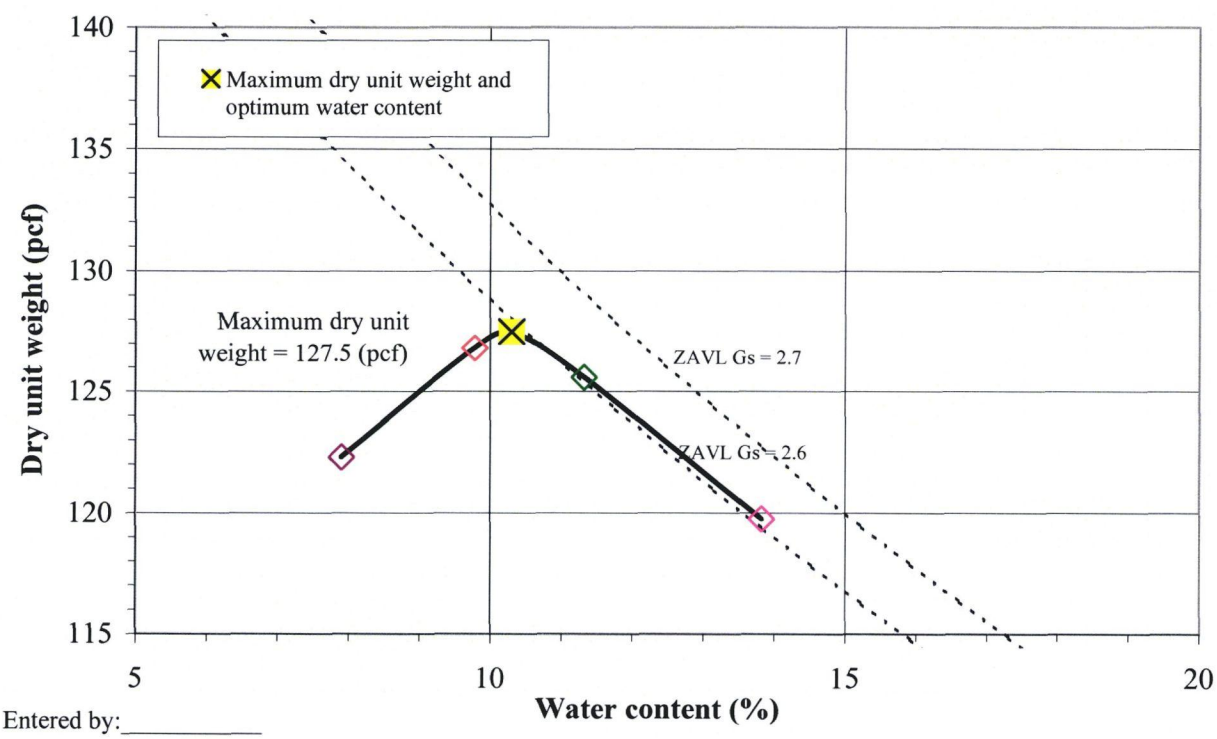
Point Number	+2%	+4%	+6%	+8%				
Wt. Sample + Mold (g)	11036.5	11283.9	11304.1	11184.7				
Wt. of Mold (g)	6537.5	6537.5	6537.5	6537.5				
Wet Unit Wt., γ_m (pcf)	132.0	139.2	139.8	136.3				
Wet Soil + Tare (g)	1497.90	1501.86	1439.76	1431.35				
Dry Soil + Tare (g)	1422.13	1409.40	1338.74	1314.21				
Tare (g)	462.95	464.17	446.58	467.02				
Water Content, w (%)	**7.9**	**9.8**	**11.3**	**13.8**				
Dry Unit Wt., γ_d (pcf)	**122.3**	**126.8**	**125.6**	**119.8**				

*Correction of Unit Weight and Water Content for Soils Containing Oversize Particles

(ASTM D4718)

Corrected water content (%): 8.4
Corrected dry unit weight (pcf): 134.0

Oversized fraction, +3/4-in. (%): 21.2
Water content, +3/4-in. (%): 1.6
Sieve for oversized fraction: 3/4-in.
Bulk specific gravity, Gs: 2.65 Assumed



Entered by:_____
Reviewed:_____

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Laboratory Compaction Characteristics of Soil

(ASTM D698 / D1557)

IGES

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Project: CS Mining Existing Facility Expansion
No: 01640-001 (II)
Location: Milford, UT
Date: 3/14/2013
By: BRR

Boring No.: TP-4
Sample:
Depth: 5-6'
Sample Description: Light brown clayey sand with gravel
Engineering Classification: Not requested
As-received water content (%): Not requested

Method: ASTM D698 B
Mold Id. Inc 3
Mold volume (ft^3): 0.0332

Preparation method: Moist
Rammer: Mechanical-circular face
Rock Correction: Yes * See results below
Percent fraction retained, Pc (%) 5.0
Percent fraction passing, Pf (%) 95.0

Optimum water content (%): 13.6
Maximum dry unit weight (pcf): 120.7

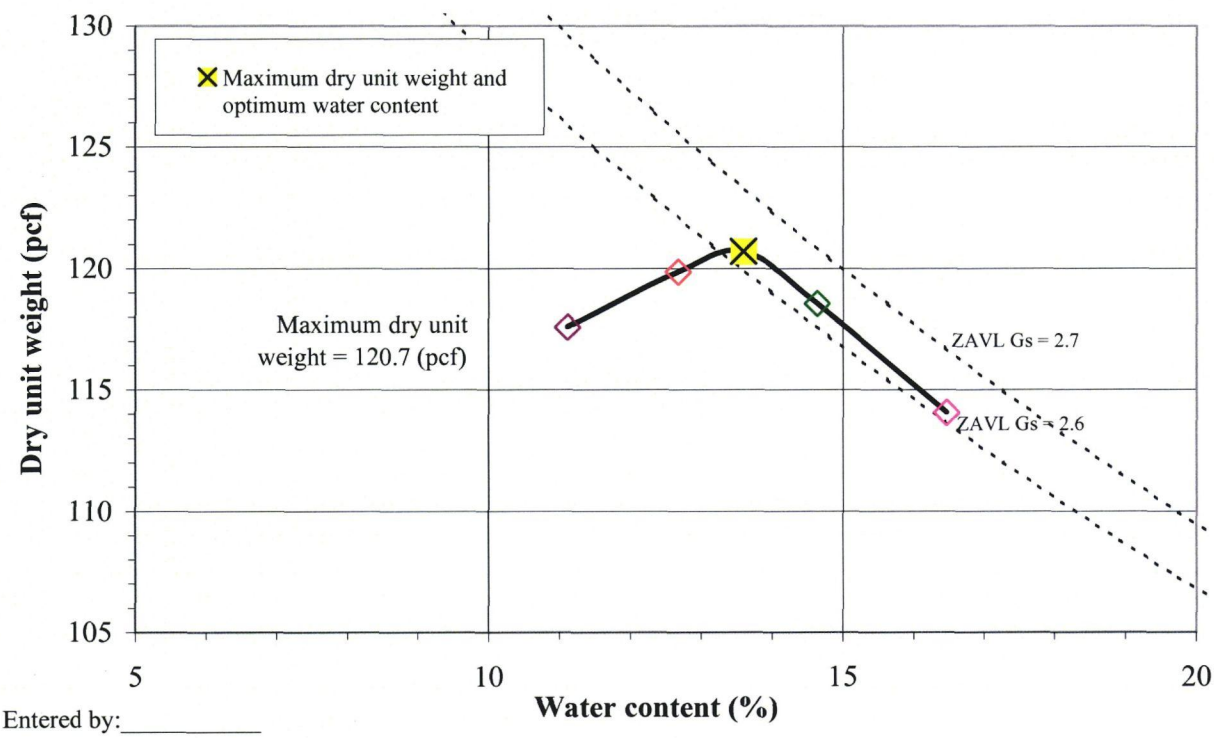
Point Number	+6%	+8%	+10%	12%				
Wt. Sample + Mold (g)	6142.0	6208.0	6221.0	6175.0				
Wt. of Mold (g)	4172.7	4172.7	4172.7	4172.7				
Wet Unit Wt., γ_m (pcf)	130.7	135.0	135.9	132.9				
Wet Soil + Tare (g)	776.60	818.73	849.93	786.20				
Dry Soil + Tare (g)	713.04	741.04	757.80	692.40				
Tare (g)	141.35	128.10	128.25	122.74				
Water Content, w (%)	**11.1**	**12.7**	**14.6**	**16.5**				
Dry Unit Wt., γ_d (pcf)	**117.6**	**119.9**	**118.6**	**114.1**				

*Correction of Unit Weight and Water Content for Soils Containing Oversize Particles

(ASTM D4718)

Oversized fraction, +3/8-in. (%): 5.0
Water content, +3/8-in. (%): 1.7
Sieve for oversized fraction: 3/8-in.
Bulk specific gravity, Gs: 2.65 Assumed

Corrected water content (%): 13.0
Corrected dry unit weight (pcf): 122.4



Entered by:_____

Reviewed:_____

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Laboratory Compaction Characteristics of Soil

(ASTM D698 / D1557)

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Project: CS Mining Existing Facility Expansion
No: 01640-001 (II)
Location: Milford, UT
Date: 3/14/2013
By: BRR

Boring No.: TP-5
Sample: Combined Samples
Depth: 3-4' & 6'
Sample Description: Brown silty sand with gravel
Engineering Classification: Not requested
As-received water content (%): Not requested

Method: ASTM D698 C
Mold Id. Inc 4
Mold volume (ft^3): 0.0751

Preparation method: Moist
Rammer: Mechanical-sector face
Rock Correction: Yes * See results below
Percent fraction retained, Pc (%) 9.9
Percent fraction passing, Pf (%) 90.1

Optimum water content (%): 13.2
Maximum dry unit weight (pcf): 115.7

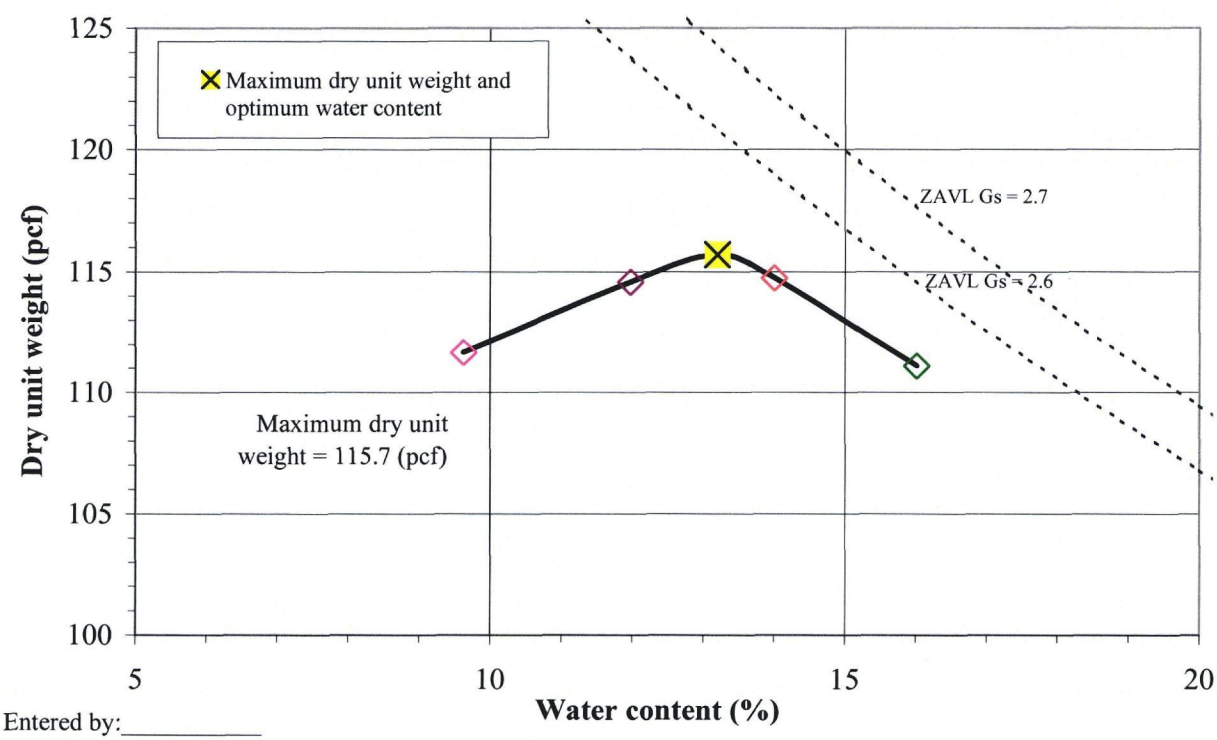
Point Number	+4%	+6%	+8%	+2%				
Wt. Sample + Mold (g)	9974.8	10060.5	9994.8	9774.5				
Wt. of Mold (g)	5603.6	5603.6	5603.6	5603.6				
Wet Unit Wt., γ_m (pcf)	128.3	130.8	128.9	122.4				
Wet Soil + Tare (g)	1366.32	1396.01	1684.65	1302.86				
Dry Soil + Tare (g)	1263.82	1263.24	1516.30	1229.55				
Tare (g)	408.01	315.59	465.15	468.01				
Water Content, w (%)	**12.0**	**14.0**	**16.0**	**9.6**				
Dry Unit Wt., γ_d (pcf)	**114.6**	**114.7**	**111.1**	**111.7**				

*Correction of Unit Weight and Water Content for Soils Containing Oversize Particles

(ASTM D4718)

Oversized fraction, +3/4-in. (%): 9.9
Water content, +3/4-in. (%): 2.3
Sieve for oversized fraction: 3/4-in.
Bulk specific gravity, Gs: 2.65 Assumed

Corrected water content (%): 12.1
Corrected dry unit weight (pcf): 119.2



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Laboratory Compaction Characteristics of Soil

(ASTM D698 / D1557)

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Project: CS Mining Existing Facility Expansion
No: 01640-001 (II)
Location: Milford, UT
Date: 3/13/2013
By: BRR

Boring No.: TP-6
Sample: Combined Samples
Depth: 2-3' & 5-6'
Sample Description: Brown silty sand with gravel
Engineering Classification: Not requested
As-received water content (%): Not requested

Method: ASTM D698 C
Mold Id. Inc 4
Mold volume (ft^3): 0.0751

Preparation method: Moist
Rammer: Mechanical-sector face
Rock Correction: Yes * See results below
Percent fraction retained, Pc (%) 17.6
Percent fraction passing, Pf (%) 82.4

Optimum water content (%): 14.5
Maximum dry unit weight (pcf): 115.5

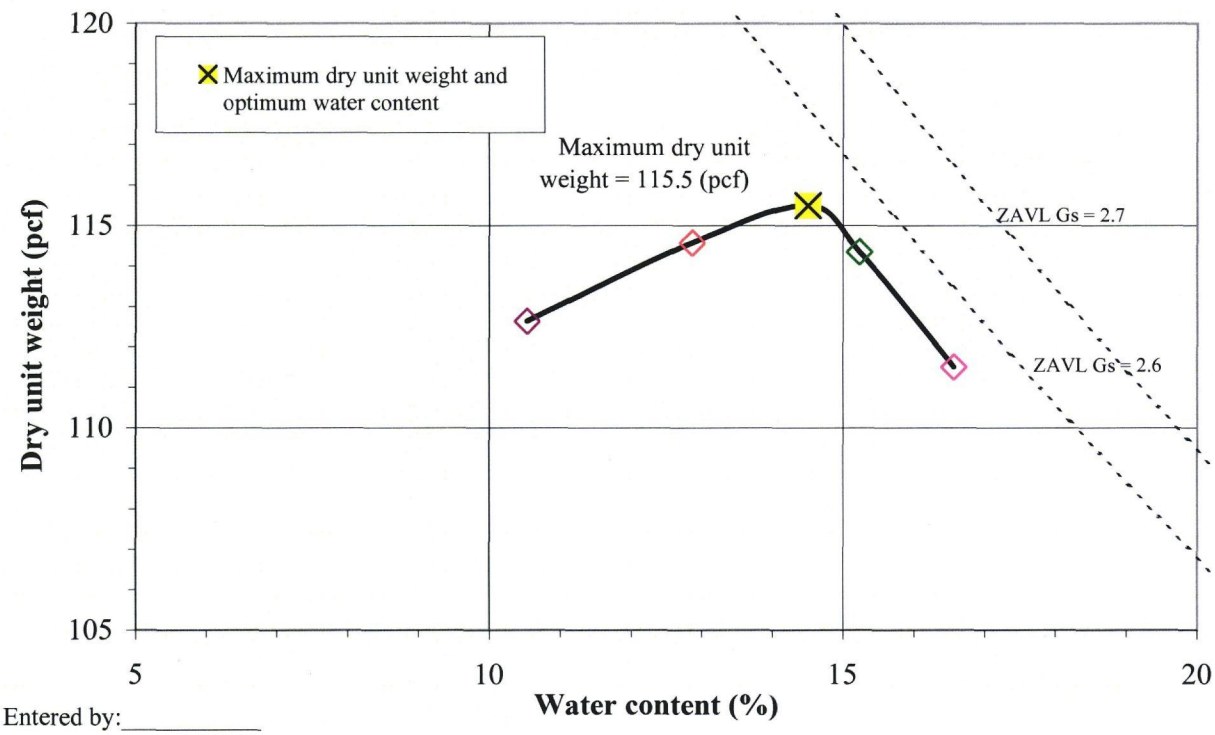
Point Number	+4%	+6%	+8%	+10%				
Wt. Sample + Mold (g)	9845.5	10009.5	10093.2	10032.2				
Wt. of Mold (g)	5603.7	5603.7	5603.7	5603.7				
Wet Unit Wt., γ_m (pcf)	124.5	129.3	131.8	130.0				
Wet Soil + Tare (g)	1254.57	1281.81	1467.16	1315.03				
Dry Soil + Tare (g)	1164.52	1171.07	1325.15	1172.12				
Tare (g)	309.79	310.45	393.09	309.56				
Water Content, w (%)	**10.5**	**12.9**	**15.2**	**16.6**				
Dry Unit Wt., γ_d (pcf)	**112.6**	**114.6**	**114.4**	**111.5**				

*Correction of Unit Weight and Water Content for Soils Containing Oversize Particles

(ASTM D4718)

Oversized fraction, +3/4-in. (%): 17.6
Water content, +3/4-in. (%): 2.5
Sieve for oversized fraction: 3/4-in.
Bulk specific gravity, Gs: 2.65 Assumed

Corrected water content (%): 12.4
Corrected dry unit weight (pcf): 122.0



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Laboratory Compaction Characteristics of Soil

(ASTM D698 / D1557)

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Project: CS Mining Existing Facility Expansion
No: 01640-001 (II)
Location: Milford, UT
Date: 3/14/2013
By: BRR

Boring No.: TP-7
Sample:
Depth: 2-3'
Sample Description: Brown sand with silt
Engineering Classification: Not requested
As-received water content (%): Not requested

Method: ASTM D698 B
Mold Id. Inc 2
Mold volume (ft^3): 0.0332

Preparation method: Moist
Rammer: Mechanical-circular face
Rock Correction: Yes * See results below
Percent fraction retained, Pc (%) 5.4
Percent fraction passing, Pf (%) 94.6

Optimum water content (%): 12.8
Maximum dry unit weight (pcf): 118.3

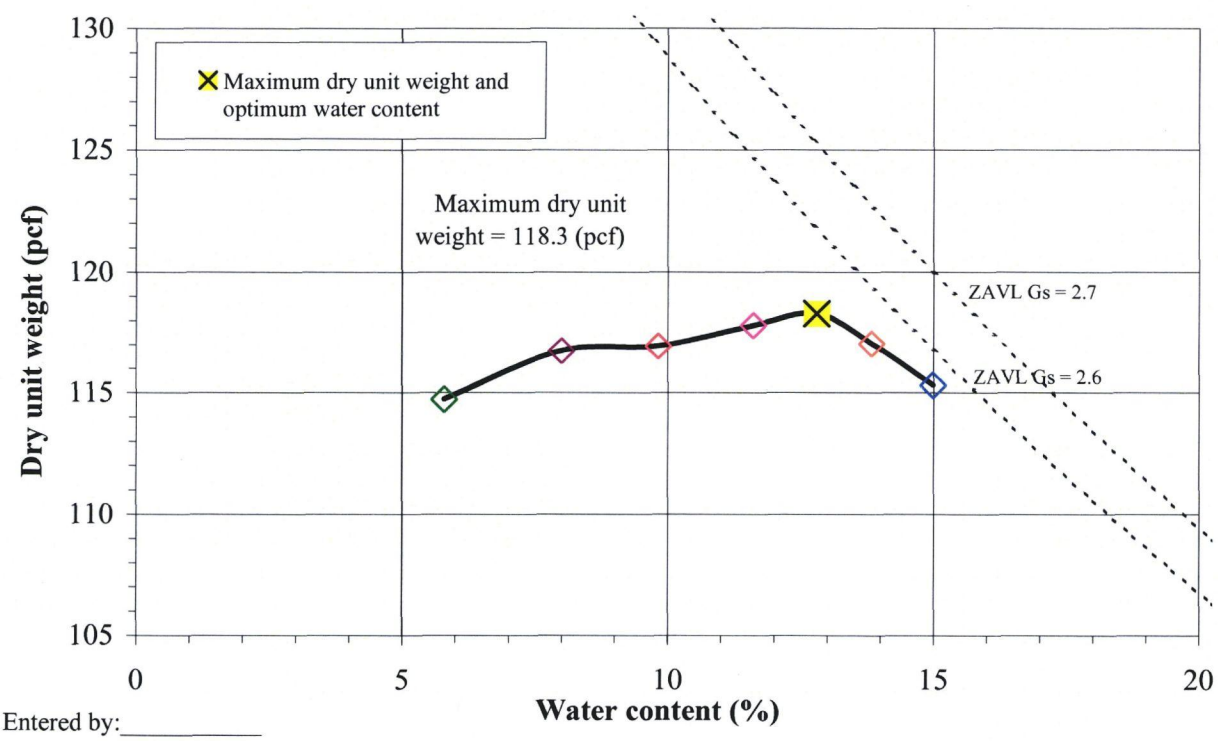
Point Number	+4%	+6%	+2%	+8%	+10%	+12%		
Wt. Sample + Mold (g)	6062.8	6098.2	5992.0	6144.3	6170.8	6161.2		
Wt. of Mold (g)	4163	4163	4163	4163	4163	4163		
Wet Unit Wt., γ_m (pcf)	126.1	128.4	121.4	131.5	133.2	132.6		
Wet Soil + Tare (g)	777.61	707.66	718.70	808.25	842.04	617.74		
Dry Soil + Tare (g)	729.36	655.45	686.13	737.36	755.10	553.87		
Tare (g)	126.14	123.99	123.46	127.14	127.00	127.76		
Water Content, w (%)	**8.0**	**9.8**	**5.8**	**11.6**	**13.8**	**15.0**		
Dry Unit Wt., γ_d (pcf)	**116.7**	**116.9**	**114.7**	**117.8**	**117.0**	**115.3**		

*Correction of Unit Weight and Water Content for Soils Containing Oversize Particles

(ASTM D4718)

Oversized fraction, +3/8-in. (%): 5.4
Water content, +3/8-in. (%): 1.7
Sieve for oversized fraction: 3/8-in.
Bulk specific gravity, Gs: 2.65 Assumed

Corrected water content (%): 12.2
Corrected dry unit weight (pcf): 120.1



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Laboratory Compaction Characteristics of Soil

(ASTM D698 / D1557)

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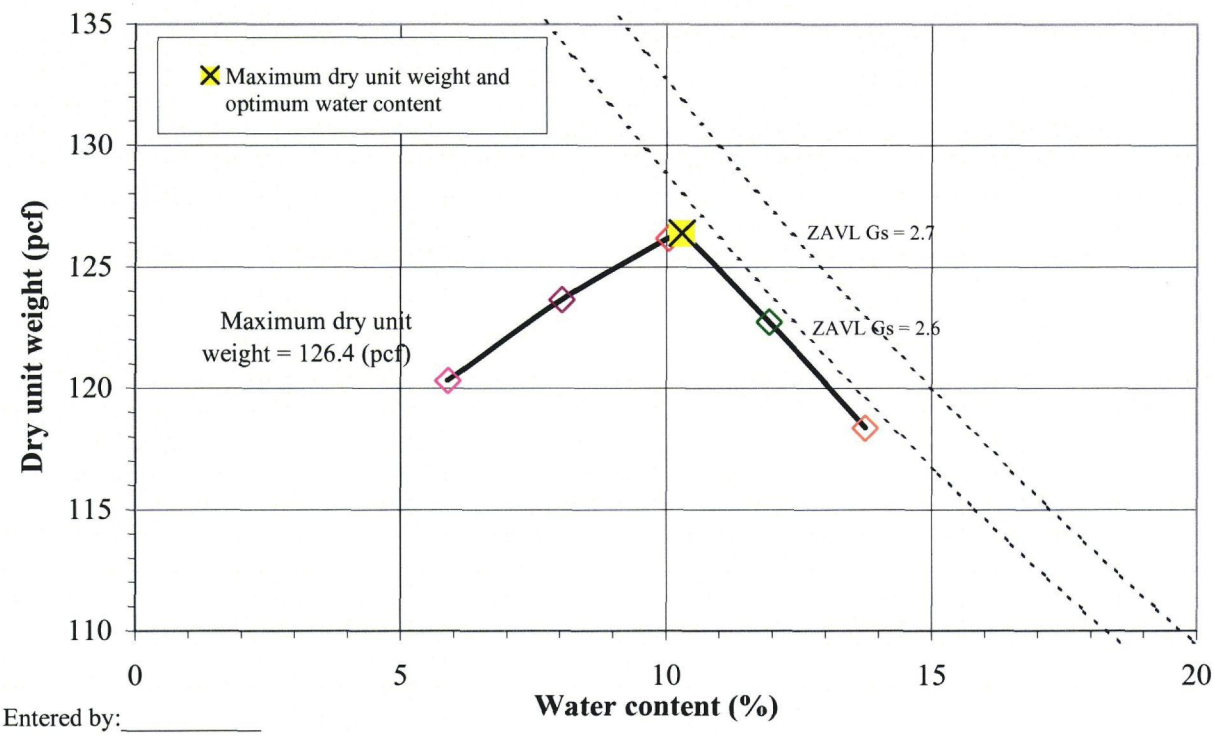
Project: CS Mining Existing Facility Expansion
No: 01640-001 (II)
Location: Milford, UT
Date: 3/14/2013
By: BRR

Method: ASTM D698 B
Mold Id. Inc 1
Mold volume (ft^3): 0.0333

Boring No.: TP-8
Sample:
Depth: 3-4'
Sample Description: Brown silty sand
Engineering Classification: Not requested
As-received water content (%): Not requested
Preparation method: Moist
Rammer: Mechanical-circular face
Rock Correction: No

Optimum water content (%): 10.3
Maximum dry unit weight (pcf): 126.4

Point Number	+4%	+6%	+8%	+2%	+10%			
Wt. Sample + Mold (g)	6265.9	6345.6	6323.1	6172.5	6281.8			
Wt. of Mold (g)	4248.2	4248.2	4248.2	4248.2	4248.2			
Wet Unit Wt., γ_m (pcf)	133.6	138.9	137.4	127.4	134.7			
Wet Soil + Tare (g)	787.32	752.37	774.06	712.33	679.61			
Dry Soil + Tare (g)	738.15	695.40	706.39	679.83	612.83			
Tare (g)	126.70	128.46	139.72	127.59	127.35			
Water Content, w (%)	**8.0**	**10.0**	**11.9**	**5.9**	**13.8**			
Dry Unit Wt., γ_d (pcf)	**123.7**	**126.2**	**122.7**	**120.3**	**118.4**			



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Laboratory Compaction Characteristics of Soil

(ASTM D698 / D1557)

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Project: CS Mining Existing Facility Expansion
No: 01640-001 (II)
Location: Milford, UT
Date: 3/14/2013
By: BRR

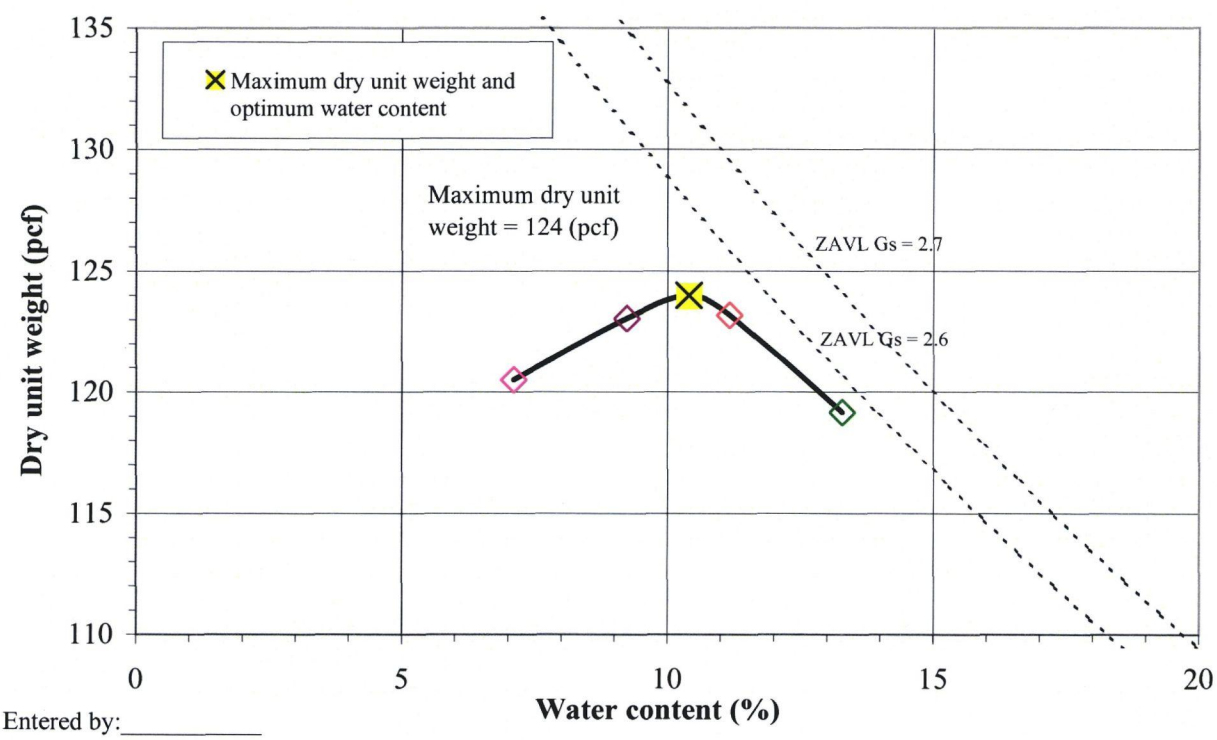
Boring No.: TP-9
Sample:
Depth: 3-4'
Sample Description: Brown silty sand
Engineering Classification: Not requested
As-received water content (%): Not requested

Method: ASTM D698 B
Mold Id. Inc 2
Mold volume (ft^3): 0.0332

Preparation method: Moist
Rammer: Mechanical-circular face
Rock Correction: No

Optimum water content (%): 10.4
Maximum dry unit weight (pcf): 124

Point Number	+4%	+6%	+8%	+2%				
Wt. Sample + Mold (g)	6188.6	6226.7	6197.2	6107.8				
Wt. of Mold (g)	4163	4163	4163	4163				
Wet Unit Wt., γ_m (pcf)	134.4	137.0	135.0	129.1				
Wet Soil + Tare (g)	804.60	663.23	806.50	702.87				
Dry Soil + Tare (g)	747.35	608.96	726.45	664.48				
Tare (g)	127.56	123.03	123.82	124.00				
Water Content, w (%)	9.2	11.2	13.3	7.1				
Dry Unit Wt., γ_d (pcf)	123.1	123.2	119.2	120.5				



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Direct Shear Test for Soils Under Drained Conditions

(ASTM D3080)

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Project: CS Mining Existing Facility Expansion
No: 01640-001 (II)
Location: Milford, UT
Date: 3/25/2013
By: JDF

Boring No.: TP-5
Sample:
Depth: 3-4' & 6'
Sample Description: Brown silty sand
Sample type: Laboratory compacted
Dry unit weight 109.9 pcf
at 15.2 (%) w
Compaction specifications: 95% of ASTM D698B

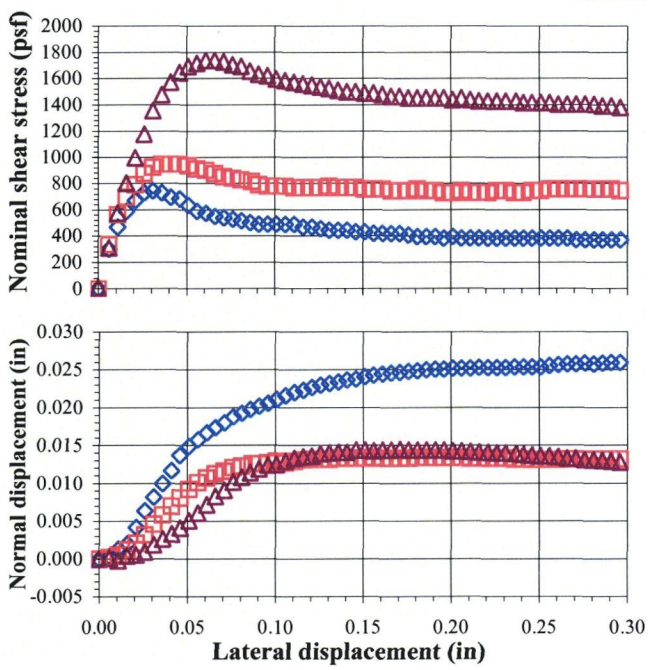
Test type: Inundated
Lateral displacement (in.): 0.3
Shear rate (in./min): 0.0200
Specific gravity, Gs: 2.65 Assumed

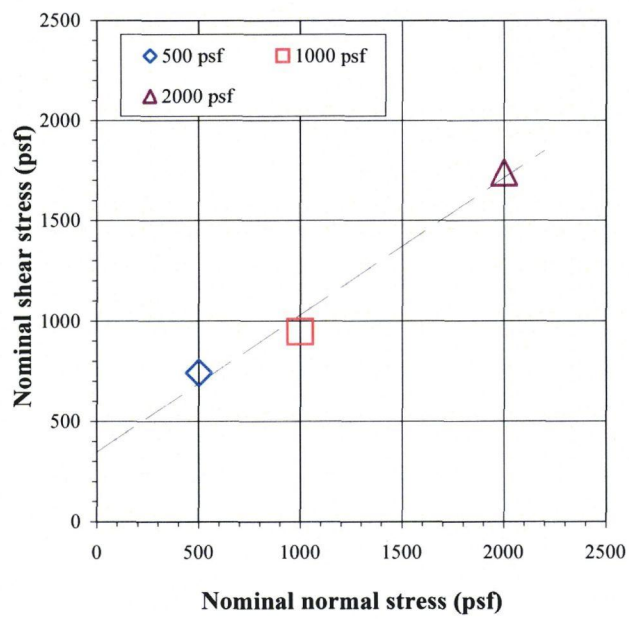
	Sample 1		Sample 2		Sample 3	
Nominal normal stress (psf)	500		1000		2000	
Peak shear stress (psf)	744		948		1740	
Lateral displacement at peak (in)	0.031		0.036		0.061	
	Initial	Pre-shear	Initial	Pre-shear	Initial	Pre-shear
Sample height (in)	1.0000	0.9908	1.0000	0.9844	1.0000	0.9833
Sample diameter (in)	2.416	2.416	2.416	2.416	2.416	2.416
Wt. rings + wet soil (g)	195.73	200.12	194.84	198.74	198.78	202.60
Wt. rings (g)	43.22	43.22	42.33	42.33	46.27	46.27
Wet soil + tare (g)	293.90	178.84	293.90	178.04	293.90	175.93
Dry soil + tare (g)	272.14	153.77	272.14	153.90	272.14	151.57
Tare (g)	128.56	21.12	128.56	22.22	128.56	20.91
Water content (%)	15.2	18.5	15.2	18.1	15.2	18.0
Dry unit weight (pcf)	110.1	111.0	110.1	111.7	110.1	111.9
Void ratio, e, for assumed Gs	0.50	0.49	0.50	0.48	0.50	0.48
Saturation (%)*	79.8	100.0	79.8	100.0	79.8	100.0

ϕ' (deg)	34
c' (psf)	348

Average of 3 samples	Initial	Pre-shear
Water content (%)	15.2	18.2
Dry unit weight (pcf)	110.1	111.5

*Pre-shear saturation set to 100% for phase calculations





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Nominal normal stress = 500 psf			Nominal normal stress = 1000 psf			Nominal normal stress = 2000 psf		
Lateral Displacement (in.)	Nominal Shear Stress (psf)	Normal Displacement (in.)	Lateral Displacement (in.)	Nominal Shear Stress (psf)	Normal Displacement (in.)	Lateral Displacement (in.)	Nominal Shear Stress (psf)	Normal Displacement (in.)
0	0	0.0000	0	0	0.0000	0	12	0.0000
0.006	300	0.0003	0.006	336	0.0002	0.006	312	0.0001
0.011	468	0.0013	0.011	564	0.0005	0.011	576	-0.0002
0.016	588	0.0020	0.016	696	0.0012	0.016	804	0.0004
0.021	672	0.0042	0.021	792	0.0021	0.021	996	0.0005
0.026	732	0.0064	0.026	876	0.0032	0.026	1176	0.0009
0.031	744	0.0082	0.031	924	0.0046	0.031	1356	0.0019
0.036	732	0.0100	0.036	948	0.0058	0.036	1476	0.0026
0.041	696	0.0117	0.041	948	0.0070	0.041	1572	0.0033
0.046	684	0.0137	0.046	948	0.0081	0.046	1644	0.0041
0.051	636	0.0149	0.051	936	0.0092	0.051	1692	0.0051
0.056	588	0.0158	0.056	912	0.0101	0.056	1716	0.0061
0.061	576	0.0167	0.061	900	0.0107	0.061	1740	0.0072
0.066	552	0.0174	0.066	876	0.0113	0.066	1740	0.0083
0.071	540	0.0180	0.071	852	0.0116	0.071	1728	0.0091
0.076	528	0.0188	0.076	840	0.0121	0.076	1704	0.0102
0.081	516	0.0193	0.081	828	0.0123	0.081	1692	0.0108
0.086	504	0.0198	0.087	816	0.0126	0.086	1656	0.0114
0.091	492	0.0202	0.091	792	0.0126	0.091	1632	0.0119
0.096	492	0.0206	0.096	780	0.0127	0.096	1620	0.0124
0.101	492	0.0211	0.101	780	0.0129	0.101	1596	0.0125
0.106	492	0.0216	0.106	780	0.0127	0.106	1584	0.0129
0.111	492	0.0220	0.111	768	0.0129	0.111	1572	0.0133
0.116	468	0.0223	0.116	768	0.0131	0.116	1560	0.0135
0.121	468	0.0227	0.121	768	0.0132	0.121	1548	0.0136
0.126	456	0.0230	0.126	768	0.0132	0.126	1536	0.0139
0.131	444	0.0232	0.131	780	0.0132	0.131	1524	0.0140
0.136	444	0.0234	0.136	768	0.0133	0.136	1512	0.0141
0.141	444	0.0237	0.141	768	0.0133	0.141	1500	0.0141
0.146	432	0.0238	0.146	768	0.0133	0.146	1500	0.0144
0.151	432	0.0241	0.151	756	0.0133	0.151	1488	0.0144
0.156	420	0.0243	0.156	756	0.0134	0.156	1488	0.0143
0.161	420	0.0245	0.161	756	0.0133	0.161	1476	0.0144
0.166	420	0.0246	0.166	744	0.0133	0.166	1464	0.0144
0.171	420	0.0247	0.171	744	0.0133	0.171	1464	0.0145
0.176	408	0.0248	0.176	744	0.0133	0.176	1452	0.0144
0.181	396	0.0249	0.181	756	0.0134	0.181	1452	0.0144
0.186	396	0.0250	0.186	744	0.0134	0.186	1452	0.0144
0.191	396	0.0251	0.191	744	0.0134	0.191	1452	0.0144
0.196	384	0.0251	0.196	732	0.0134	0.196	1452	0.0144
0.201	396	0.0252	0.201	732	0.0134	0.201	1440	0.0143
0.206	384	0.0252	0.206	744	0.0134	0.206	1452	0.0143
0.211	384	0.0252	0.211	732	0.0133	0.211	1440	0.0142
0.216	384	0.0253	0.216	732	0.0133	0.216	1428	0.0141
0.221	384	0.0253	0.221	732	0.0133	0.221	1428	0.0141
0.226	384	0.0253	0.226	744	0.0133	0.226	1428	0.0140
0.231	384	0.0253	0.231	744	0.0133	0.231	1428	0.0140
0.236	384	0.0254	0.236	732	0.0132	0.237	1428	0.0139
0.241	384	0.0254	0.241	732	0.0132	0.241	1416	0.0138
0.246	384	0.0254	0.246	744	0.0131	0.246	1416	0.0137
0.251	384	0.0254	0.251	744	0.0131	0.251	1416	0.0136
0.256	384	0.0256	0.256	756	0.0131	0.256	1416	0.0136
0.261	384	0.0257	0.261	756	0.0131	0.261	1404	0.0135
0.266	384	0.0258	0.266	756	0.0132	0.266	1404	0.0133
0.271	372	0.0258	0.271	756	0.0132	0.271	1404	0.0133
0.276	372	0.0259	0.276	756	0.0131	0.276	1404	0.0131
0.281	372	0.0258	0.281	756	0.0132	0.281	1404	0.0131
0.286	372	0.0259	0.286	756	0.0132	0.286	1392	0.0130
0.291	372	0.0260	0.291	756	0.0132	0.291	1392	0.0129
0.296	372	0.0260	0.296	744	0.0132	0.296	1380	0.0128
0.301	372	0.0261	0.301	756	0.0132	0.301	1392	0.0127

Direct Shear Test for Soils Under Drained Conditions

(ASTM D3080)

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Project: CS Mining Existing Facility Expansion
No: 01640-001 (II)
Location: Milford, UT
Date: 3/25/2013
By: JDF

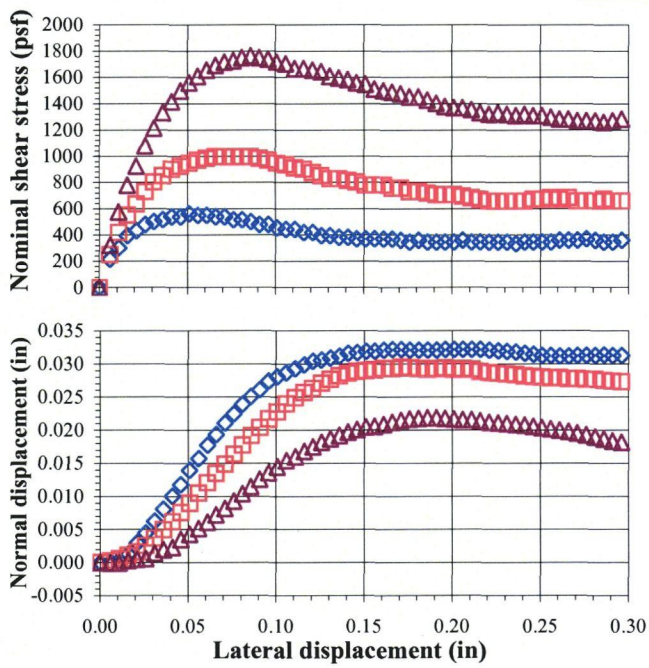
Boring No.: TP-8
Sample:
Depth: 3-4'
Sample Description: Brown silty sand
Sample type: Laboratory compacted
Dry unit weight 120.1 pcf
at 12.3 (%) w
Compaction specifications: 95% of ASTM D698B

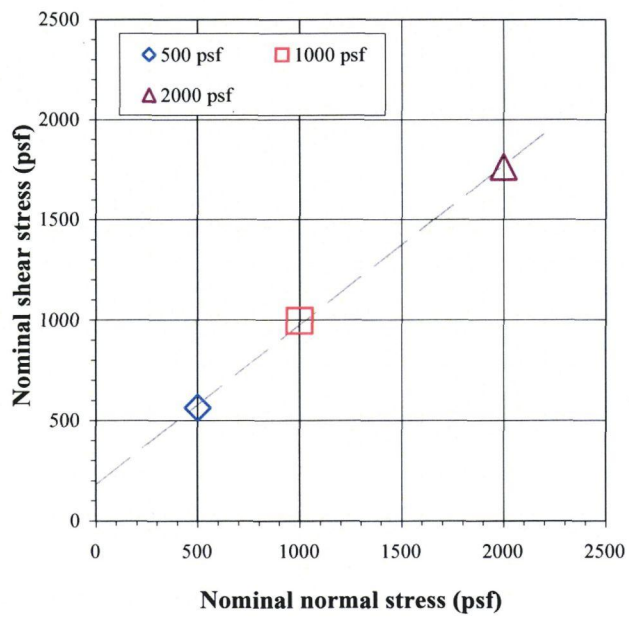
Test type: Inundated
Lateral displacement (in.): 0.3
Shear rate (in./min): 0.0172
Specific gravity, Gs: 2.65 Assumed

	Sample 1		Sample 2		Sample 3	
Nominal normal stress (psf)	500		1000		2000	
Peak shear stress (psf)	564		996		1764	
Lateral displacement at peak (in)	0.051		0.066		0.086	
	Initial	Pre-shear	Initial	Pre-shear	Initial	Pre-shear
Sample height (in)	1.0000	0.9950	1.0000	0.9903	1.0000	0.9859
Sample diameter (in)	2.416	2.416	2.416	2.416	2.416	2.416
Wt. rings + wet soil (g)	204.83	207.09	205.04	206.94	207.61	209.18
Wt. rings (g)	42.41	42.41	42.62	42.62	45.19	45.19
Wet soil + tare (g)	324.30	183.95	324.30	182.97	324.30	183.80
Dry soil + tare (g)	302.55	163.49	302.55	163.18	302.55	164.02
Tare (g)	127.94	21.06	127.94	20.67	127.94	21.78
Water content (%)	12.5	14.0	12.5	13.8	12.5	13.5
Dry unit weight (pcf)	120.0	120.6	120.0	121.1	120.0	121.7
Void ratio, e, for assumed Gs	0.38	0.37	0.38	0.37	0.38	0.36
Saturation (%)*	87.2	100.0	87.2	100.0	87.2	100.0

		Average of 3 samples	Initial	Pre-shear
ϕ' (deg)	38	Water content (%)	12.5	13.8
c' (psf)	180	Dry unit weight (pcf)	120.0	121.1

*Pre-shear saturation set to 100% for phase calculations





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Nominal normal stress = 500 psf			Nominal normal stress = 1000 psf			Nominal normal stress = 2000 psf		
Lateral Displacement (in.)	Nominal Shear Stress (psf)	Normal Displacement (in.)	Lateral Displacement (in.)	Nominal Shear Stress (psf)	Normal Displacement (in.)	Lateral Displacement (in.)	Nominal Shear Stress (psf)	Normal Displacement (in.)
0	0	0.0000	0	0	0.0000	0	0	0.0000
0.006	216	0.0001	0.006	252	0.0003	0.006	324	-0.0001
0.011	300	0.0004	0.011	420	0.0006	0.011	576	-0.0001
0.016	396	0.0013	0.016	552	0.0011	0.016	780	0.0003
0.021	432	0.0030	0.021	636	0.0016	0.021	924	0.0005
0.026	480	0.0045	0.026	732	0.0026	0.026	1080	0.0006
0.031	504	0.0063	0.031	804	0.0037	0.031	1212	0.0014
0.036	516	0.0081	0.036	852	0.0050	0.036	1332	0.0020
0.041	540	0.0101	0.041	900	0.0062	0.041	1416	0.0023
0.046	540	0.0118	0.046	924	0.0076	0.046	1500	0.0035
0.051	564	0.0140	0.051	948	0.0090	0.051	1560	0.0043
0.056	552	0.0158	0.056	972	0.0105	0.056	1608	0.0052
0.061	552	0.0178	0.061	984	0.0121	0.061	1656	0.0061
0.066	540	0.0194	0.066	996	0.0135	0.066	1692	0.0072
0.071	540	0.0211	0.071	996	0.0149	0.071	1716	0.0082
0.076	516	0.0225	0.076	996	0.0164	0.076	1728	0.0093
0.081	516	0.0240	0.081	996	0.0178	0.081	1752	0.0104
0.086	504	0.0251	0.086	996	0.0192	0.086	1764	0.0115
0.091	480	0.0261	0.091	984	0.0204	0.091	1752	0.0126
0.096	480	0.0274	0.096	972	0.0217	0.096	1740	0.0136
0.101	456	0.0281	0.101	948	0.0228	0.101	1716	0.0145
0.106	444	0.0287	0.106	936	0.0240	0.106	1704	0.0154
0.111	444	0.0293	0.111	912	0.0249	0.111	1668	0.0160
0.116	420	0.0299	0.116	900	0.0257	0.116	1668	0.0168
0.121	420	0.0304	0.121	876	0.0263	0.121	1656	0.0175
0.126	396	0.0306	0.126	852	0.0271	0.126	1644	0.0182
0.131	396	0.0309	0.131	828	0.0277	0.131	1608	0.0187
0.136	384	0.0312	0.136	828	0.0282	0.136	1596	0.0192
0.141	384	0.0316	0.141	816	0.0286	0.141	1584	0.0197
0.146	372	0.0317	0.146	804	0.0289	0.146	1560	0.0201
0.151	372	0.0319	0.151	780	0.0290	0.151	1548	0.0205
0.156	372	0.0319	0.156	780	0.0291	0.156	1512	0.0206
0.161	372	0.0321	0.161	780	0.0293	0.161	1500	0.0209
0.166	372	0.0322	0.166	756	0.0293	0.166	1488	0.0212
0.171	360	0.0322	0.171	756	0.0295	0.171	1476	0.0215
0.176	348	0.0321	0.176	732	0.0294	0.176	1452	0.0217
0.181	360	0.0321	0.181	732	0.0293	0.181	1452	0.0218
0.186	348	0.0321	0.186	720	0.0292	0.186	1428	0.0219
0.191	348	0.0321	0.191	708	0.0293	0.191	1404	0.0219
0.196	348	0.0322	0.196	708	0.0294	0.196	1380	0.0218
0.201	348	0.0322	0.201	708	0.0292	0.201	1368	0.0217
0.206	360	0.0322	0.206	696	0.0293	0.206	1368	0.0216
0.211	348	0.0322	0.211	684	0.0292	0.211	1356	0.0216
0.216	348	0.0322	0.216	672	0.0289	0.216	1332	0.0214
0.221	348	0.0321	0.221	660	0.0287	0.221	1320	0.0212
0.226	348	0.0320	0.226	660	0.0286	0.226	1332	0.0211
0.231	348	0.0319	0.231	660	0.0285	0.231	1320	0.0210
0.236	336	0.0318	0.236	660	0.0284	0.236	1308	0.0209
0.241	348	0.0316	0.241	660	0.0282	0.241	1320	0.0208
0.246	348	0.0315	0.246	672	0.0281	0.246	1308	0.0206
0.251	348	0.0313	0.251	672	0.0280	0.251	1308	0.0204
0.256	348	0.0313	0.256	684	0.0279	0.256	1296	0.0202
0.261	360	0.0312	0.261	672	0.0279	0.261	1284	0.0200
0.266	360	0.0312	0.266	684	0.0278	0.266	1284	0.0198
0.271	360	0.0313	0.271	660	0.0278	0.271	1272	0.0196
0.276	372	0.0313	0.276	660	0.0277	0.276	1272	0.0193
0.281	360	0.0313	0.281	660	0.0277	0.281	1272	0.0190
0.286	348	0.0314	0.286	672	0.0275	0.286	1260	0.0187
0.291	348	0.0313	0.291	660	0.0274	0.291	1272	0.0184
0.296	360	0.0313	0.296	660	0.0273	0.296	1284	0.0182
0.301	348	0.0313	0.301	672	0.0270	0.301	1284	0.0180

Direct Shear Test for Soils Under Drained Conditions

(ASTM D3080)

IGES

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Project: CS Mining Existing Facility Expansion
No: 01640-001 (II)
Location: Milford, UT
Date: 3/25/2013
By: JDF

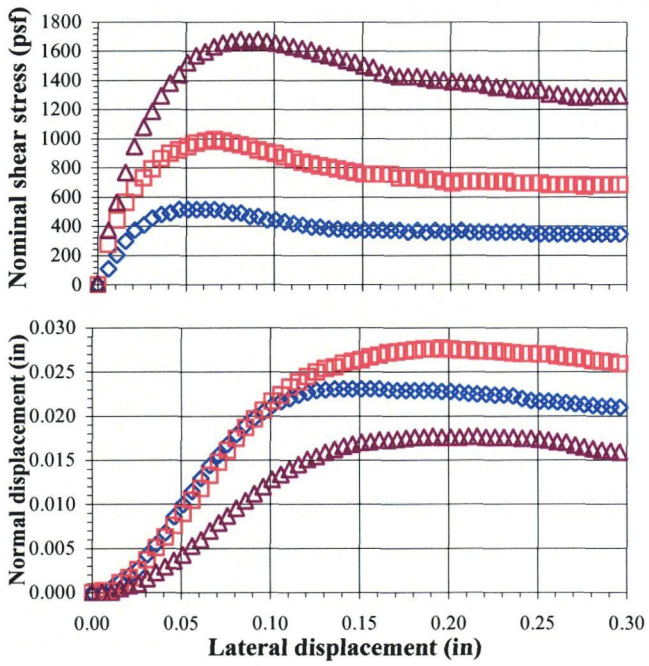
Boring No.: TP-9
Sample:
Depth: 3-4'
Sample Description: Brown silty sand
Sample type: Laboratory compacted
Dry unit weight 117.8 pcf
at 12.4 (%) w
Compaction specifications: 95% of ASTM D698B

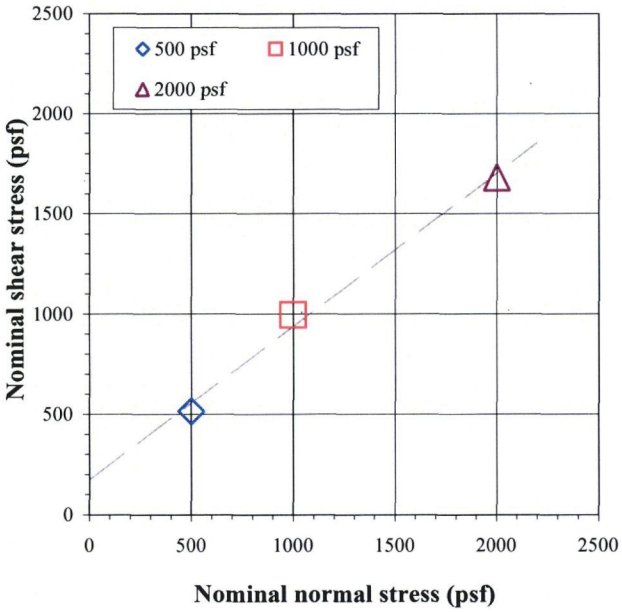
Test type: Inundated
Lateral displacement (in.): 0.3
Shear rate (in./min): 0.0172
Specific gravity, Gs: 2.65 Assumed

	Sample 1		Sample 2		Sample 3	
Nominal normal stress (psf)	500		1000		2000	
Peak shear stress (psf)	516		996		1680	
Lateral displacement at peak (in)	0.046		0.066		0.081	
	Initial	Pre-shear	Initial	Pre-shear	Initial	Pre-shear
Sample height (in)	1.0000	0.9937	1.0000	0.9894	1.0000	0.9838
Sample diameter (in)	2.416	2.416	2.416	2.416	2.416	2.416
Wt. rings + wet soil (g)	205.96	209.47	202.61	205.80	203.34	206.11
Wt. rings (g)	46.48	46.48	43.13	43.13	43.86	43.86
Wet soil + tare (g)	263.21	181.72	263.21	181.24	263.21	182.40
Dry soil + tare (g)	247.90	161.22	247.90	161.33	247.90	162.60
Tare (g)	124.46	21.06	124.46	21.30	124.46	22.49
Water content (%)	12.4	14.9	12.4	14.7	12.4	14.4
Dry unit weight (pcf)	117.9	118.6	117.9	119.1	117.9	119.8
Void ratio, e, for assumed Gs	0.40	0.39	0.40	0.39	0.40	0.38
Saturation (%)*	81.5	100.0	81.5	100.0	81.5	100.0

		Average of 3 samples	Initial	Pre-shear
ϕ' (deg)	37	Water content (%)	12.4	14.6
c' (psf)	174	Dry unit weight (pcf)	117.9	119.2

*Pre-shear saturation set to 100% for phase calculations





Entered by:_____
Reviewed:_____

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Nominal normal stress = 500 psf			Nominal normal stress = 1000 psf			Nominal normal stress = 2000 psf		
Lateral Displacement (in.)	Nominal Shear Stress (psf)	Normal Displacement (in.)	Lateral Displacement (in.)	Nominal Shear Stress (psf)	Normal Displacement (in.)	Lateral Displacement (in.)	Nominal Shear Stress (psf)	Normal Displacement (in.)
0	0	0.0000	0	0	0.0000	0	12	0.0000
0.006	108	0.0002	0.006	276	0.0002	0.006	372	0.0000
0.011	204	0.0006	0.011	444	0.0002	0.011	564	0.0000
0.016	300	0.0013	0.016	564	0.0011	0.016	768	0.0005
0.021	372	0.0019	0.021	660	0.0017	0.021	948	0.0008
0.026	408	0.0027	0.026	732	0.0026	0.026	1080	0.0010
0.031	456	0.0043	0.031	792	0.0037	0.031	1188	0.0016
0.036	480	0.0055	0.036	864	0.0051	0.036	1296	0.0023
0.041	492	0.0068	0.041	900	0.0063	0.041	1380	0.0029
0.046	516	0.0086	0.046	924	0.0076	0.046	1440	0.0036
0.051	516	0.0100	0.051	948	0.0090	0.051	1524	0.0043
0.056	516	0.0115	0.056	972	0.0105	0.056	1572	0.0053
0.061	516	0.0130	0.061	984	0.0118	0.061	1596	0.0060
0.066	516	0.0144	0.066	996	0.0133	0.066	1632	0.0070
0.071	504	0.0156	0.071	984	0.0148	0.071	1656	0.0079
0.076	492	0.0168	0.076	972	0.0161	0.076	1668	0.0087
0.081	492	0.0179	0.081	960	0.0175	0.081	1680	0.0096
0.086	468	0.0190	0.086	948	0.0187	0.086	1668	0.0104
0.091	468	0.0198	0.091	924	0.0197	0.091	1680	0.0112
0.096	444	0.0205	0.096	912	0.0207	0.096	1668	0.0120
0.101	444	0.0212	0.101	900	0.0217	0.101	1656	0.0128
0.106	432	0.0217	0.106	876	0.0224	0.106	1644	0.0134
0.111	420	0.0220	0.111	864	0.0233	0.111	1632	0.0140
0.116	408	0.0224	0.116	840	0.0239	0.116	1620	0.0145
0.121	396	0.0227	0.121	828	0.0245	0.121	1608	0.0151
0.126	396	0.0229	0.126	816	0.0250	0.126	1584	0.0154
0.131	384	0.0230	0.131	804	0.0254	0.131	1572	0.0159
0.136	384	0.0231	0.136	792	0.0256	0.136	1560	0.0162
0.141	372	0.0231	0.141	780	0.0260	0.141	1536	0.0166
0.146	372	0.0231	0.146	768	0.0262	0.146	1524	0.0168
0.151	372	0.0231	0.151	756	0.0264	0.151	1500	0.0170
0.156	372	0.0231	0.156	756	0.0267	0.156	1488	0.0171
0.161	372	0.0231	0.161	756	0.0269	0.161	1452	0.0173
0.166	372	0.0230	0.166	756	0.0272	0.166	1440	0.0173
0.171	372	0.0229	0.171	732	0.0273	0.171	1428	0.0174
0.176	360	0.0229	0.176	732	0.0274	0.176	1428	0.0175
0.181	372	0.0229	0.181	732	0.0275	0.181	1428	0.0176
0.186	360	0.0229	0.186	720	0.0276	0.186	1416	0.0176
0.191	372	0.0229	0.191	720	0.0276	0.191	1404	0.0177
0.196	360	0.0228	0.196	708	0.0277	0.196	1404	0.0176
0.201	360	0.0228	0.201	696	0.0276	0.201	1392	0.0176
0.206	372	0.0227	0.206	708	0.0275	0.206	1392	0.0176
0.211	360	0.0226	0.211	708	0.0275	0.211	1380	0.0177
0.216	360	0.0225	0.216	708	0.0274	0.216	1380	0.0177
0.221	360	0.0225	0.221	708	0.0274	0.221	1368	0.0176
0.226	360	0.0224	0.226	708	0.0274	0.226	1356	0.0176
0.231	360	0.0224	0.231	708	0.0273	0.231	1356	0.0176
0.236	360	0.0223	0.236	696	0.0272	0.236	1344	0.0176
0.241	360	0.0220	0.241	696	0.0271	0.241	1332	0.0175
0.246	348	0.0218	0.246	696	0.0271	0.246	1332	0.0175
0.251	348	0.0217	0.251	696	0.0270	0.251	1332	0.0174
0.256	348	0.0217	0.256	684	0.0270	0.256	1308	0.0173
0.261	348	0.0216	0.261	684	0.0268	0.261	1308	0.0171
0.266	348	0.0215	0.266	684	0.0267	0.266	1296	0.0170
0.271	348	0.0214	0.271	684	0.0266	0.271	1284	0.0167
0.276	348	0.0213	0.276	672	0.0265	0.276	1284	0.0165
0.281	348	0.0212	0.281	684	0.0263	0.281	1296	0.0163
0.286	348	0.0211	0.286	684	0.0262	0.286	1296	0.0161
0.291	348	0.0211	0.291	684	0.0261	0.291	1296	0.0160
0.296	348	0.0210	0.296	684	0.0259	0.296	1296	0.0159
0.301	348	0.0210	0.301	684	0.0257	0.301	1284	0.0157

Consolidated Undrained Triaxial Compression Test for Cohesive Soils

(ASTM D4767)

IGES

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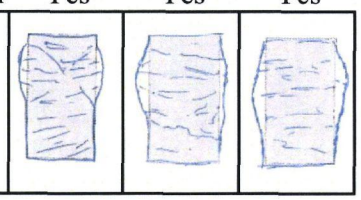
Project: CS Mining Existing Facility
No: 01640-001(II)
Location: Milford, UT
Date: 3/25/2013
By: MP

Boring No.: TP-3
Sample:
Depth: 1-3'
Sample Description: Brown silty sand
Engineering Classification: Not requested
Sample type: Laboratory compacted

	Test Number:	S1	S2	S3
Initial	Height, H (in)	5.970	5.989	5.997
	Diameter, D (in)	2.422	2.420	2.420
	Water content, w (%)	12.1	12.1	12.1
	Dry unit weight, γ_d (pcf)	121.4	121.2	121.1
	Saturation (%)	88.4	88.0	87.6
	Void ratio, e	0.36	0.36	0.37
	Mounting	Wet	Wet	Wet
Before shear	Water content, w (%)	14.7	14.6	14.6
	Dry unit weight, γ_d (pcf)	119.1	119.2	119.3
	Saturation[a] (%)	100.0	100.0	100.0
	Void ratio, e	0.39	0.39	0.39
	Area, A_{eoc} (in^2)	4.69	4.72	4.65
	Area method	A	A	A
	B	0.95	0.95	0.95
	t_{50} (min)	0.15	0.15	0.11
	Back pressure (psf)	6407	9791	6912
	Strain rate (%/min)	0.06	0.06	0.06
	Time to failure (min)	333.3	78.3	66.7
	Strain at failure, ε_f (%)	20.00	4.70	4.00
	Filter paper correction	No	No	No
	Membrane correction	Yes	Yes	Yes
Assumed specific gravity 2.65				

[a] Saturation set to 100% for phase calculations

Summary of strength parameters at peak deviator stress		
Total stress	c (psf)	1076
	ϕ (deg)	19.5
Effective stress	c' (psf)	77
	ϕ' (deg)	37.1

Comments:

Specimens were compacted to 95% of the MDUW at OWC +2%. The maximum dry unit weight and optimum water content from the Proctor test was 127.5 pcf and 10.3% respectively.

Tested by:_____

Reviewed:_____

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Consolidated Undrained Triaxial Compression Test for Cohesive Soils

(ASTM D4767)

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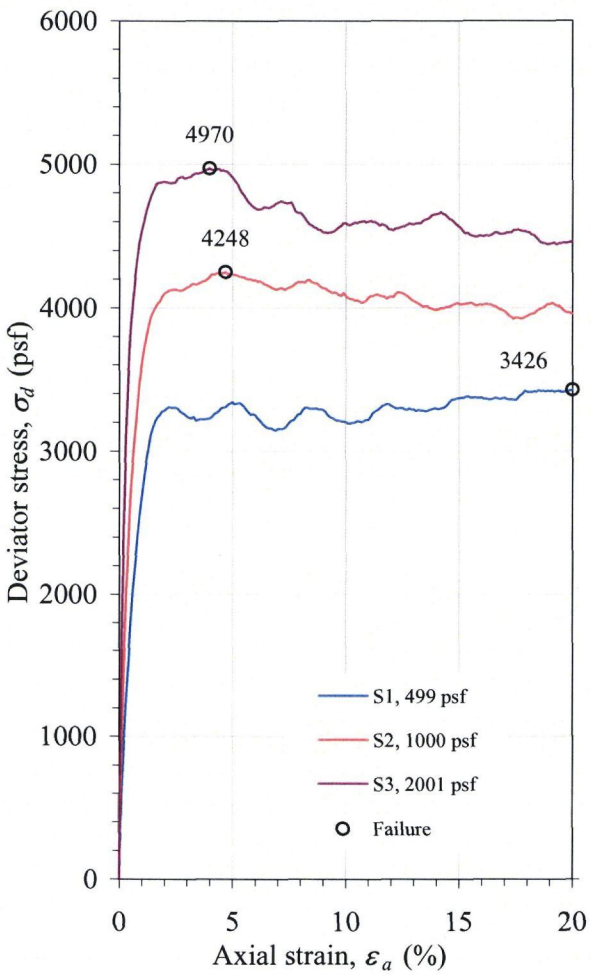
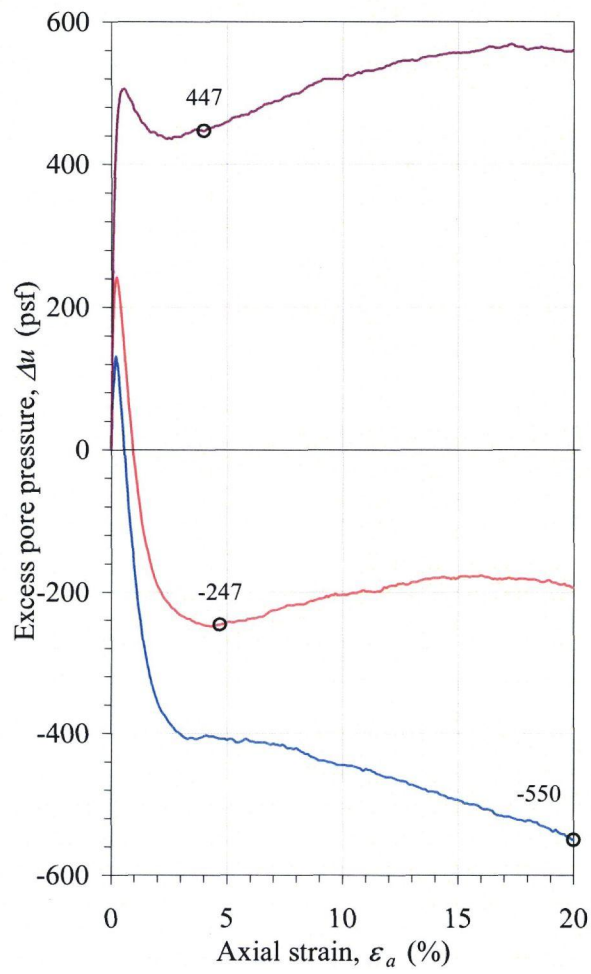
Project: CS Mining Existing Facility
No: 01640-001(II)
Location: Milford, UT

Boring No.: TP-3
Sample:
Depth: 1-3'

	Test Number:	S1	S2	S3
Total stress	σ_3 (psf)	499	1000	2001
	σ_1-σ_3 (psf)	3426	4248	4970
	σ_1 (psf)	3925	5248	6972
	$q = (\sigma_1-\sigma_3)/2$ (psf)	1713	2124	2485
	$p = (\sigma_1+\sigma_3)/2$ (psf)	2212	3124	4486
Effective stress	Δu (psf)	-550	-247	447
	σ'_3 (psf)	1049	1247	1555
	σ'_1-σ'_3 (psf)	3426	4248	4970
	σ'_1 (psf)	4475	5494	6525
	$q = (\sigma'_1-\sigma'_3)/2$ (psf)	1713	2124	2485
	$p' = (\sigma'_1+\sigma'_3)/2$ (psf)	2762	3371	4040
	σ'_1/σ'_3	4.26	4.41	4.20
	$A = \Delta u/(\sigma_1-\sigma_3)$	-0.161	-0.058	0.090





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Consolidated Undrained Triaxial Compression Test for Cohesive Soils

(*ASTM D4767*)

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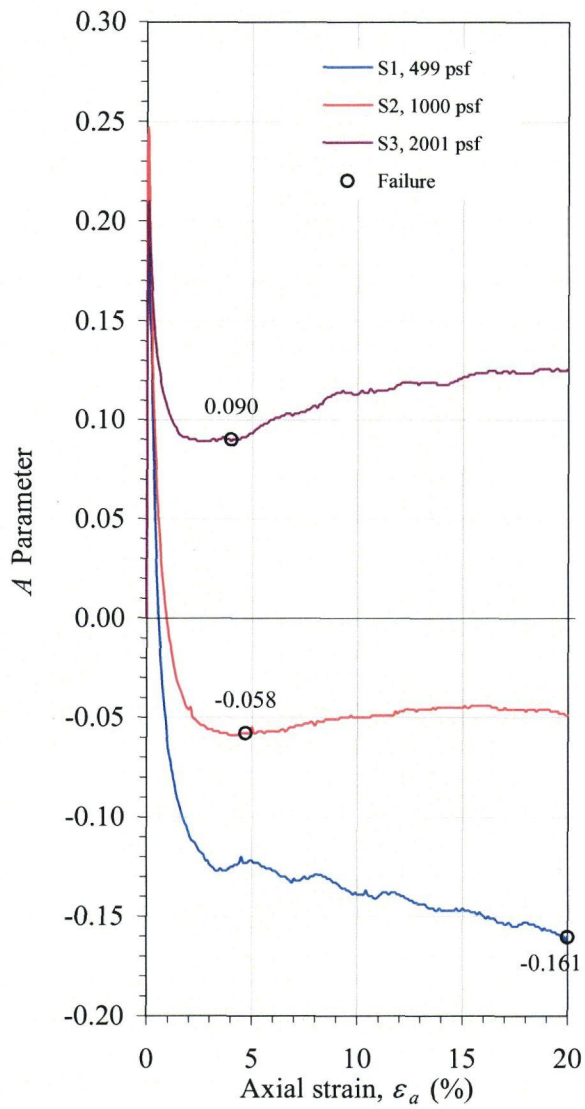
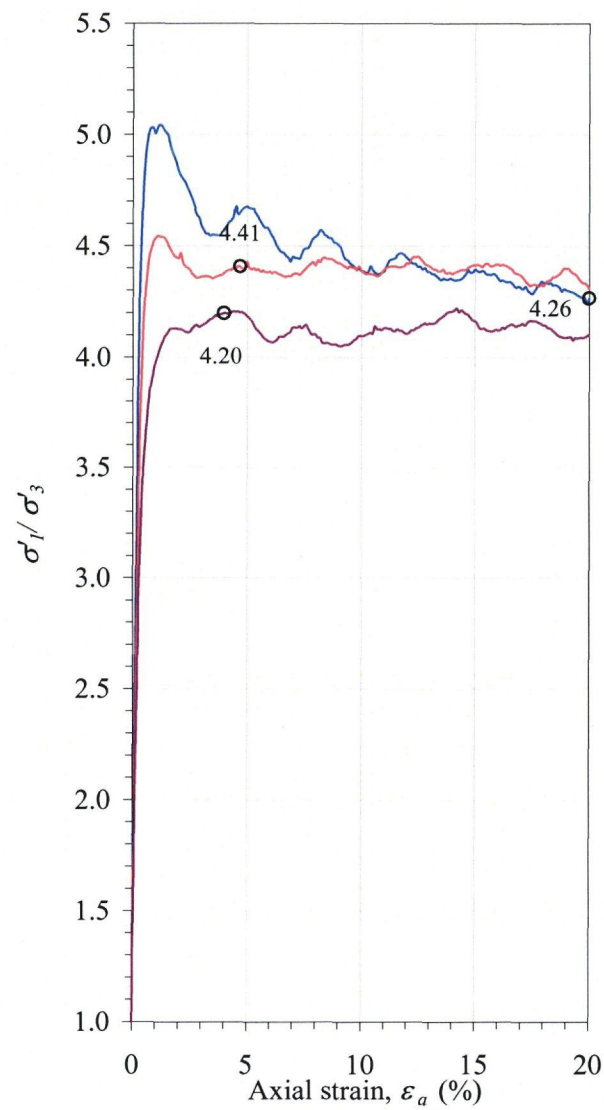
Project: CS Mining Existing Facility
No: 01640-001(II)
Location: Milford, UT

Boring No.: TP-3
Sample:
Depth: 1-3'

Summary of strength parameters at peak deviator stress		
Total stress	c (psf)	1076
	ϕ (deg)	19.5
Effective stress	c' (psf)	77
	ϕ' (deg)	37.1





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Consolidated Undrained Triaxial Compression Test for Cohesive Soils

(ASTM D4767)

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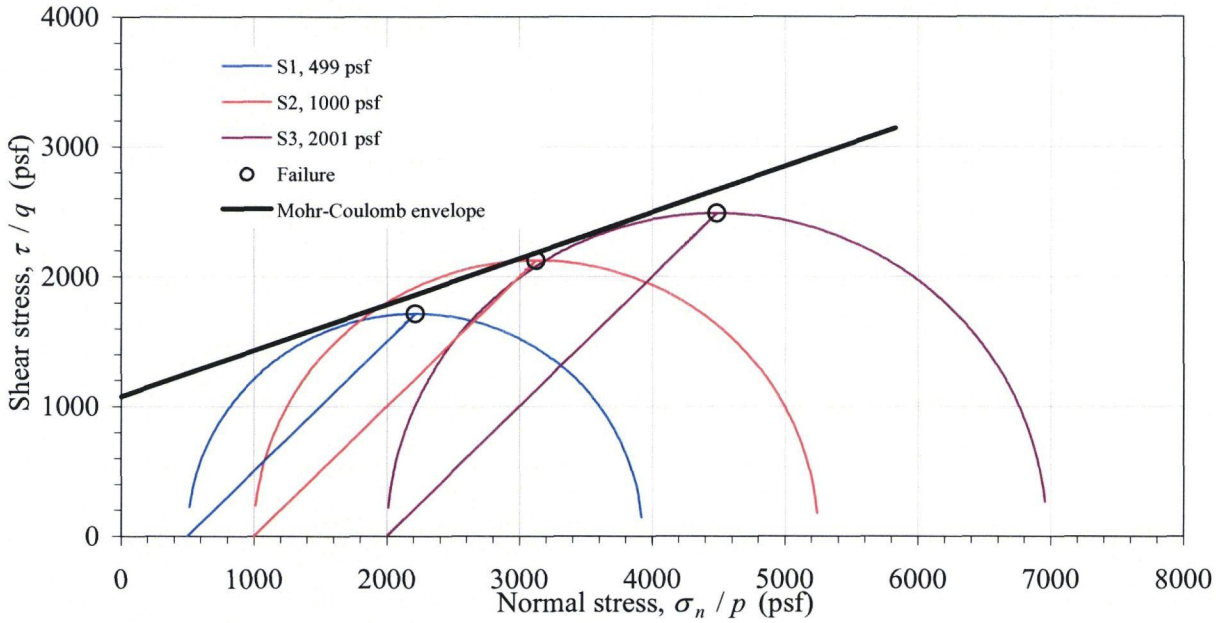
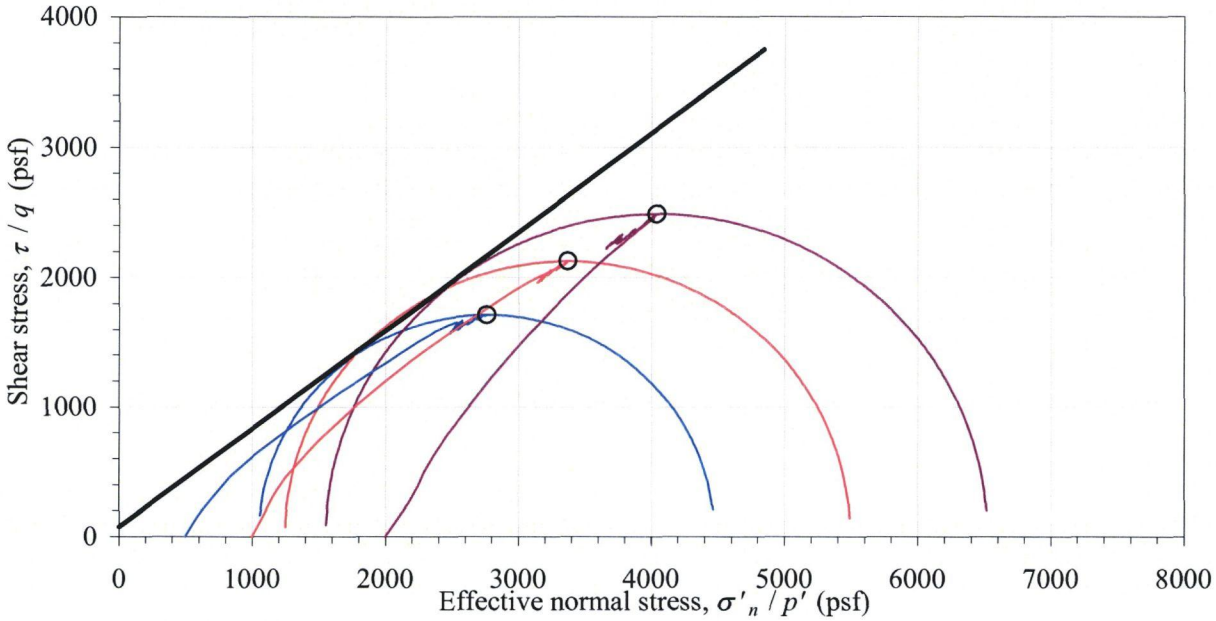
Project: CS Mining Existing Facility
No: 01640-001(II)
Location: Milford, UT

Boring No.: TP-3
Sample:
Depth: 1-3'

Summary of strength parameters at peak deviator stress		
Total stress	c (psf)	1076
	ϕ (deg)	19.5
Effective stress	c' (psf)	77
	ϕ' (deg)	37.1





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Consolidated Undrained Triaxial Compression Test for Cohesive Soils

(*ASTM D4767*)

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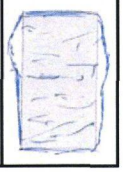
Project: CS Mining Existing Facility Expansion
No: 01640-001 (II)
Location: Milford, UT
Date: 3/22/2013
By: MP

Boring No.: TP-6
Sample:
Depth: 2-6'
Sample Description: Brown silty sand
Engineering Classification: Not requested
Sample type: Laboratory compacted

	Test Number:	S1	S2	S3
Initial	Height, H (in)	6.000	5.994	5.976
	Diameter, D (in)	2.419	2.421	2.419
	Water content, w (%)	16.5	16.5	16.5
	Dry unit weight, γ_d (pcf)	109.5	109.4	109.7
	Saturation (%)	85.8	85.6	86.3
	Void ratio, e	0.51	0.51	0.51
	Mounting	Wet	Wet	Wet
Before shear	Water content, w (%)	20.0	19.7	20.0
	Dry unit weight, γ_d (pcf)	108.2	108.7	108.1
	Saturation[a] (%)	100.0	100.0	100.0
	Void ratio, e	0.53	0.52	0.53
	Area, A_{eoc} (in^2)	4.64	4.63	4.65
	Area method	A	A	A
	B	0.95	0.95	0.95
	t_{50} (min)	0.10	0.09	0.11
	Back pressure (psf)	7632	9790	8351
	Strain rate (%/min)	0.06	0.06	0.06
	Time to failure (min)	241.7	295.0	80.0
	Strain at failure, ε_f (%)	14.50	17.70	4.80
	Filter paper correction	No	No	No
	Membrane correction	Yes	Yes	Yes
Assumed specific gravity 2.65				

[a] Saturation set to 100% for phase calculations

Summary of strength parameters at peak deviator stress		
Total stress	c (psf)	1034
	ϕ (deg)	27.0
Effective stress	c' (psf)	0
	ϕ' (deg)	39.0

Comments:

Specimens were compacted to 95% of the MDUW at OWC +2%. The maximum dry unit weight and optimum water content from the Proctor test was 115.5 pcf and 14.5% respectively.

Tested by:_____

Reviewed:_____

Z:\PROJECTS\01640_CS_mining\001_Tailings\II\[GTXCU3v2_TP-6_2-6.xls]Summary

Consolidated Undrained Triaxial Compression Test for Cohesive Soils

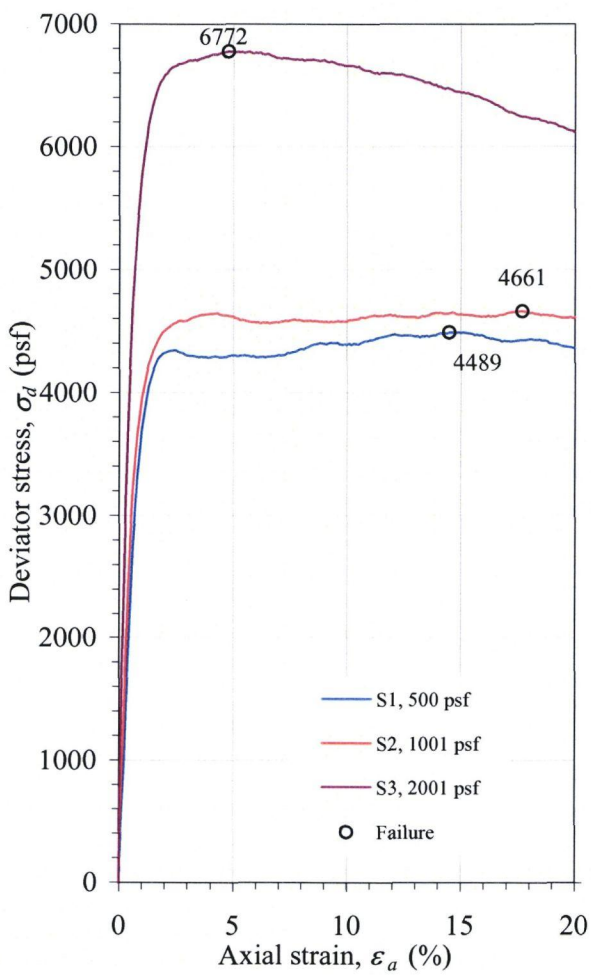
(*ASTM D4767*)

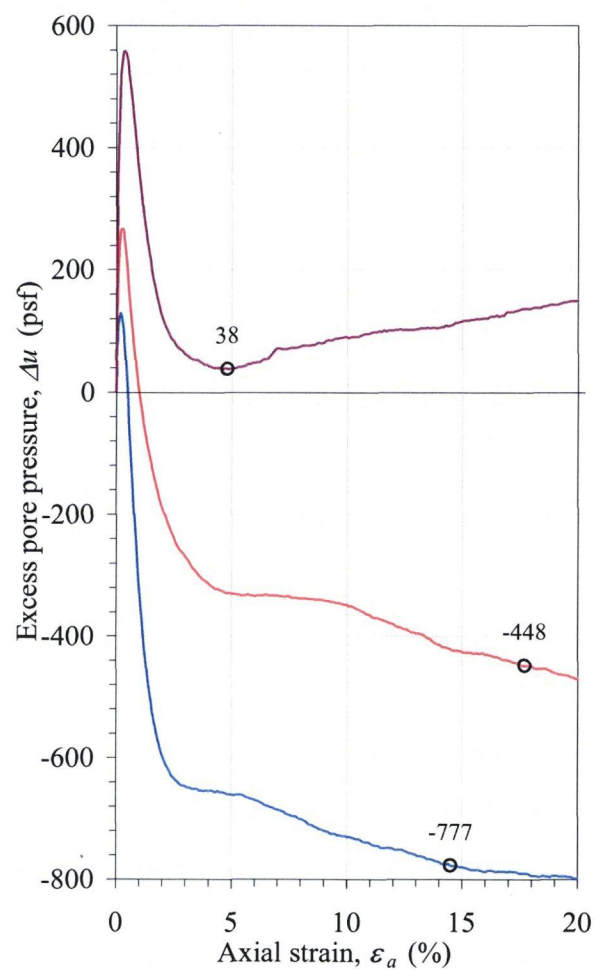
© IGES 2009, 2013

Project: CS Mining Existing Facility Expansion
No: 01640-001 (II)
Location: Milford, UT

Boring No.: TP-6
Sample:
Depth: 2-6'

	Test Number:	S1	S2	S3
Total stress	σ_3 (psf)	500	1001	2001
	σ_1-σ_3 (psf)	4489	4661	6772
	σ_1 (psf)	4989	5662	8773
	$q = (\sigma_1-\sigma_3)/2$ (psf)	2245	2330	3386
	$p = (\sigma_1+\sigma_3)/2$ (psf)	2744	3331	5387
Effective stress	Δu (psf)	-777	-448	38
	σ'_3 (psf)	1277	1449	1963
	σ'_1-σ'_3 (psf)	4489	4661	6772
	σ'_1 (psf)	5766	6110	8736
	$q = (\sigma'_1-\sigma'_3)/2$ (psf)	2245	2330	3386
	$p' = (\sigma'_1+\sigma'_3)/2$ (psf)	3521	3780	5349
	σ'_1/σ'_3	4.52	4.22	4.45
	$A = \Delta u/(\sigma_1-\sigma_3)$	-0.173	-0.096	0.006





Z:\PROJECTS\01640_CS_mining\001_Tailings\II\[GTXCU3v2_TP-6_2-6.xls]Summary

Consolidated Undrained Triaxial Compression Test for Cohesive Soils

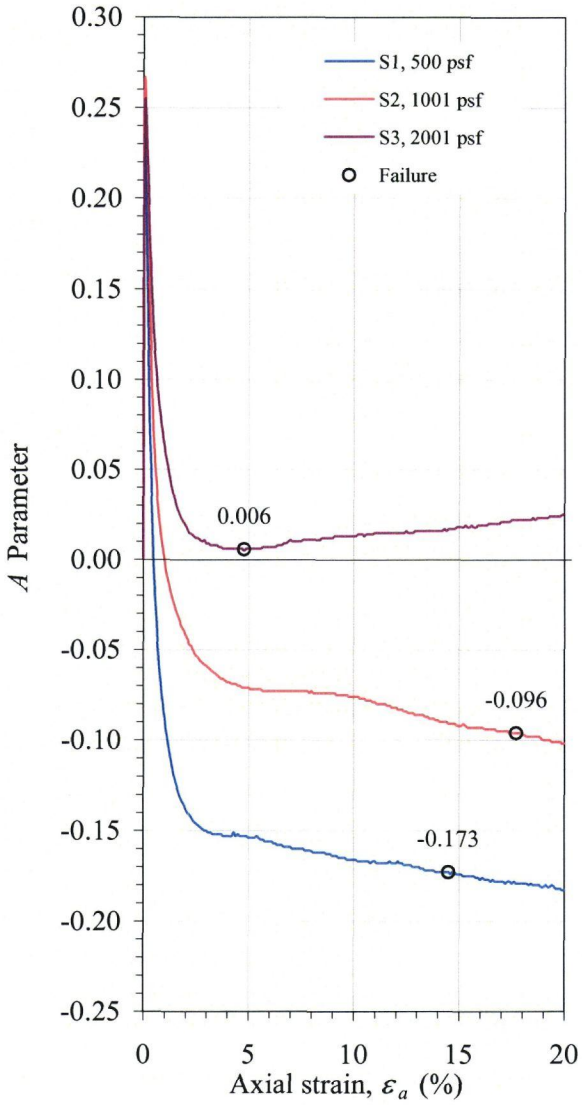
(*ASTM D4767*)

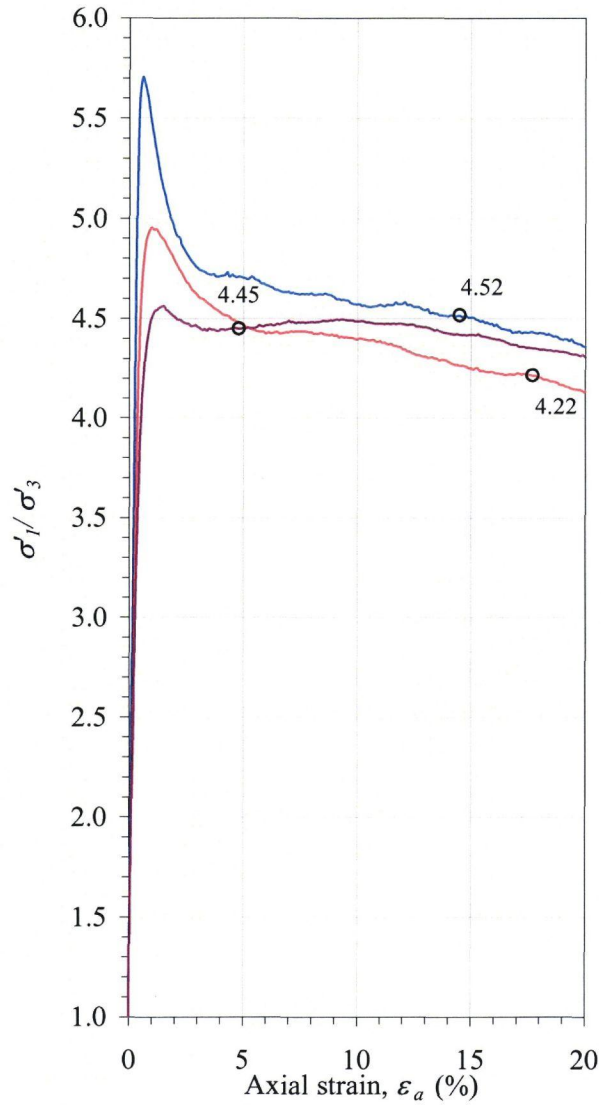
IGES
© IGES 2009, 2013

Project: CS Mining Existing Facility Expansion
No: 01640-001 (II)
Location: Milford, UT

Boring No.: TP-6
Sample:
Depth: 2-6'

Summary of strength parameters at peak deviator stress		
Total stress	c (psf)	1034
	ϕ (deg)	27.0
Effective stress	c' (psf)	0
	ϕ' (deg)	39.0





Z:\PROJECTS\01640_CS_mining\001_Tailings\II\[GTXCU3v2_TP-6_2-6.xls]Summary

Consolidated Undrained Triaxial Compression Test for Cohesive Soils

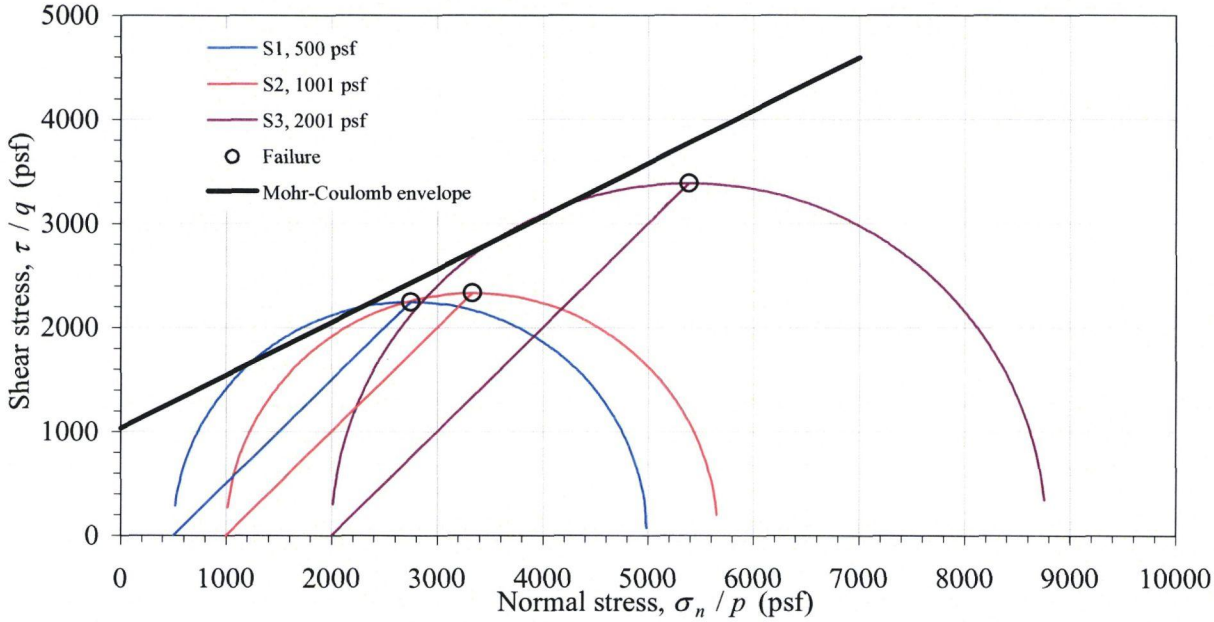
(ASTM D4767)

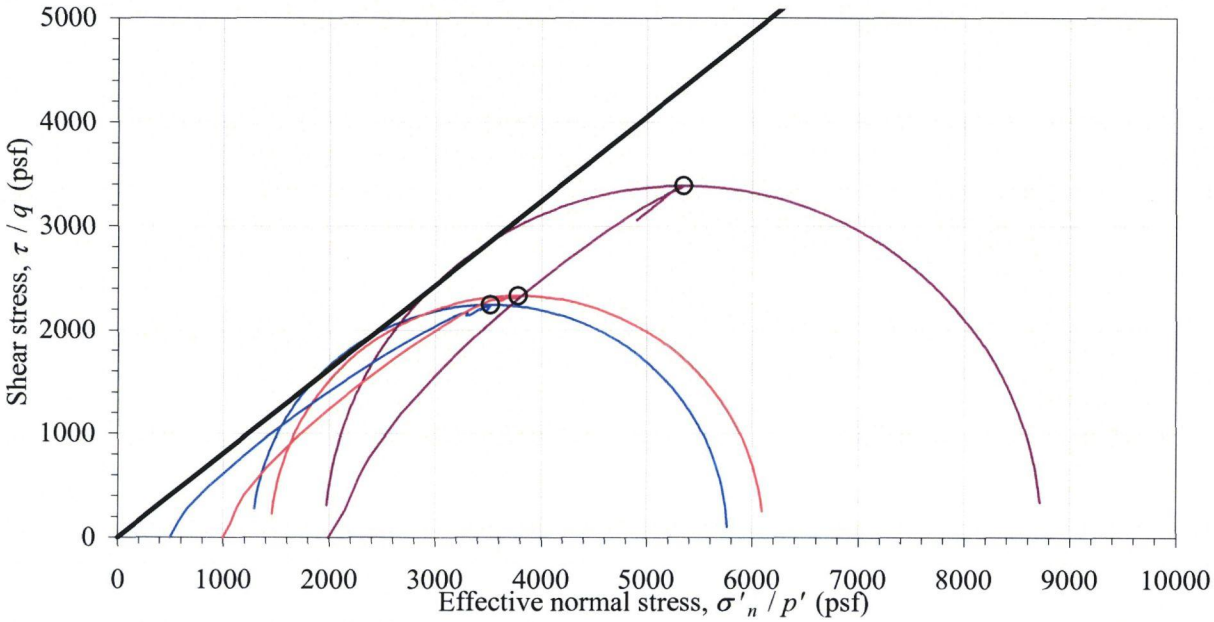
IGES
© IGES 2009, 2013

Project: CS Mining Existing Facility Expansion
No: 01640-001 (II)
Location: Milford, UT

Boring No.: TP-6
Sample:
Depth: 2-6'

Summary of strength parameters at peak deviator stress		
Total stress	c (psf)	1034
	ϕ (deg)	27.0
Effective stress	c' (psf)	0
	ϕ' (deg)	39.0





Z:\PROJECTS\01640_CS_mining\001_Tailings\II\[GTXCU3v2_TP-6_2-6.xls]Summary

Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter, Method C (ASTM D5084)

IGES

© IGES 2005, 2013

Project: CS Mining Existing Facility Expansion
No: 01640-001 (II)
Location: Milford, UT
Date: 3/20/2013
By: JDF

Boring No.: TP-3
Sample:
Depth: 1-3'

Sample Description: Brown silty sand with gravel
Sample Type: Laboratory Compacted
Compaction Specifications: 95 (%) Dry unit weight
at 12.3 (%) w

	Initial (o)	Final (f)
Sample Height, H (in)	3.010	3.001
Sample Diameter, D (in)	2.409	2.39
Sample Length, L (cm)	7.645	7.622
Sample Area, A (cm^2)	29.406	28.949
Sample Volume, V (cm^3)	224.82	220.64
Wt. Rings + Wet Soil (g)	491.1	500.21
Wt. Rings (g)	0	0
Wet Unit Wt., γ_m (pcf)	136.4	141.5
Wet Soil + Tare (g)	585.32	500.21
Dry Soil + Tare (g)	535.92	438.06
Tare (g)	127.9	0
Weight of solids, Ws (g)	438.06	438.06
Water Content, w (%)	12.11	14.19
Dry Unit Wt, γ_d (pcf)	121.6	123.9
Void ratio, e, for assumed Gs	0.36	0.38
Saturation (%), for assumed Gs	89.1	100 [a]
Average K^b (cm/sec)	**2.3E-06**	

[a] Saturation set to 100% for phase calculations
[b] K corrected to 20°C

Optimum water content (%)	10.3	
Maximum dry unit weight (pcf)	127.5	
Gs	2.65	Assumed
Cell No.	1	
Station No.	1	
Permeant liquid used	De-aired tap water	
Total backpressure (psi)	34.5	
Effective horiz. consolidation stress (psi)	10.4	
Effective vert. consolidation stress (psi)	10.4	

	Initial (o)	Final (f)
B value	0.72	0.96
External Burette (cm^3)	9.30	20.20
Cell Pressure (psi)	0.0	44.9

Backpressure bottom (psi)	34.5
Backpressure top (psi)	34.5
System volume coefficient (cm^3/psi)	0.150
System volume change (cm^3)	6.72
Net sample volume change (cm^3)	-4.18
Bottom burette ground length, l_b (cm)	82.00
Top burette ground length, l_t (cm)	82.1
Burette area, a (cm^2)	0.197
Conversion, reading to cm head (cm/rd)	5.076

Start Date and Time: 3/18/13 12:58

Elapsed time (sec)	Bottom Burette (cm^3)	Top Burette (cm^3)	h_1 (cm)	h_2 (cm)	K (cm/sec)	Temp (°C)	Visc. Ratio R_f	K^b (cm/sec)
4620.0	3.22 3.84	6.82 6.18	18.17	11.78	2.4E-06	21.3	0.97	2.4E-06
6240.0	0.00 2.20	10.00 7.78	50.66	28.22	2.4E-06	22.5	0.94	2.3E-06
4800.0	0.00 1.80	10.00 8.20	50.66	32.39	2.4E-06	19.7	1.01	2.4E-06
3480.0	1.80 2.62	8.20 7.38	32.39	24.06	2.2E-06	19.7	1.01	2.2E-06
4440.0	2.62 3.36	7.38 6.64	24.06	16.55	2.2E-06	19.4	1.02	2.2E-06

Entered by:_____
Reviewed:_____

Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter, Method C (ASTM D5084)

IGES

© IGES 2005, 2013

Project: CS Mining Exisiting Facility Expansion
No: 01640-001 (II)
Location: Milford, UT
Date: 3/19/2013
By: MP

Boring No.: TP-6
Sample:
Depth: 2-3, 5-6'
Sample Description: Brown silty sand
Sample Type: Laboratory Compacted
Compaction Specifications: 95 (%) Dry unit weight
at 16.5 (%) w

	Initial (o)	Final (f)
Sample Height, H (in)	3.009	3.001
Sample Diameter, D (in)	2.407	2.39
Sample Length, L (cm)	7.643	7.623
Sample Area, A (cm^2)	29.357	28.971
Sample Volume, V (cm^3)	224.37	220.85
Wt. Rings + Wet Soil (g)	458.95	471.816
Wt. Rings (g)	0	0
Wet Unit Wt., γ_m (pcf)	127.7	133.4
Wet Soil + Tare (g)	494	598.57
Dry Soil + Tare (g)	441.55	520.28
Tare (g)	124.47	125.05
Weight of solids, Ws (g)	393.81	393.81
Water Content, w (%)	16.54	19.81
Dry Unit Wt, γ_d (pcf)	109.6	111.3
Void ratio, e, for assumed Gs	0.51	0.52
Saturation (%), for assumed Gs	86.0	100 [a]
Average K[b] (cm/sec)	**5.9E-05**	

[a] Saturation set to 100% for phase calculations
[b] K corrected to 20°C

Optimum water content (%)	14.5	
Maximum dry unit weight (pcf)	115.5	
Gs	2.65	Assumed
Cell No.	2	
Station No.	2	
Permeant liquid used	De-aired tap water	
Total backpressure (psi)	34.5	
Effective horiz. consolidation stress (psi)	10.4	
Effective vert. consolidation stress (psi)	10.4	

	Initial (o)	Final (f)
B value	0.54	1.00
External Burette (cm^3)	8.50	19.10
Cell Pressure (psi)	0.0	44.9

Backpressure bottom (psi)	34.5
Backpressure top (psi)	34.5
System volume coefficient (cm^3/psi)	0.158
System volume change (cm^3)	7.08
Net sample volume change (cm^3)	-3.52
Bottom burette ground length, l_b (cm)	81.99
Top burette ground length, l_t (cm)	81.97
Burette area, a (cm^2)	0.197
Conversion, reading to cm head (cm/rd)	5.076

Start Date and Time: 3/18/13 13:00

Elapsed time (sec)	Bottom Burette (cm^3)	Top Burette (cm^3)	h_1 (cm)	h_2 (cm)	K (cm/sec)	Temp (°C)	Visc. Ratio R_f	K^b (cm/sec)
420.0	0.08 3.26	9.94 6.74	50.07	17.68	6.4E-05	22.1	0.95	6.1E-05
420.0	0.00 3.20	10.00 6.76	50.78	18.09	6.4E-05	22.1	0.95	6.1E-05
420.0	0.00 3.18	10.00 6.78	50.78	18.29	6.3E-05	22.1	0.95	6.0E-05
420.0	0.00 3.14	10.00 6.82	50.78	18.70	6.2E-05	22.1	0.95	5.9E-05
420.0	0.00 3.10	9.94 6.84	50.48	19.00	6.0E-05	22.1	0.95	5.7E-05

Entered by:_____
Reviewed:_____

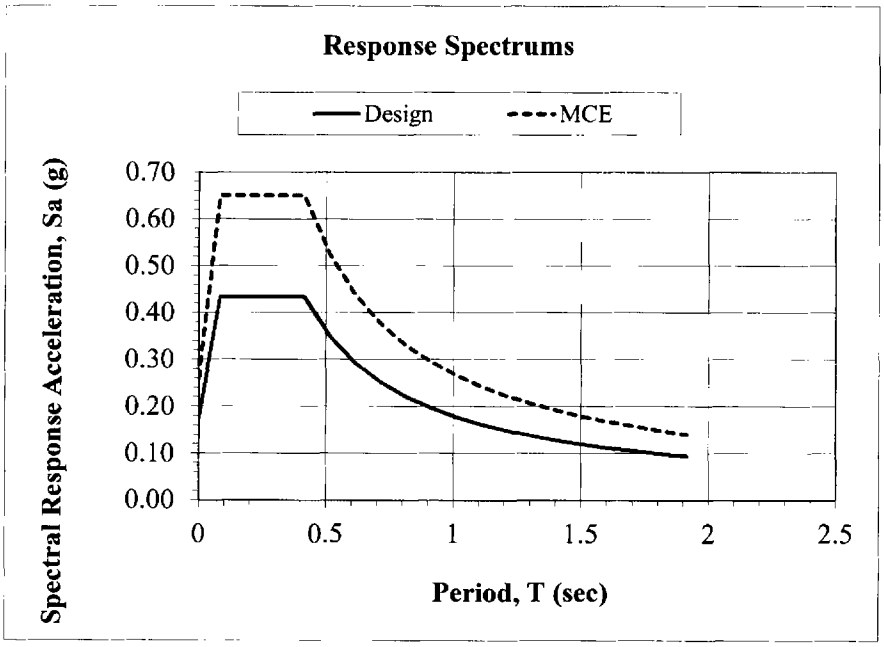
APPENDIX C

SITE GROUND MOTION [IBC SECTION 1615]

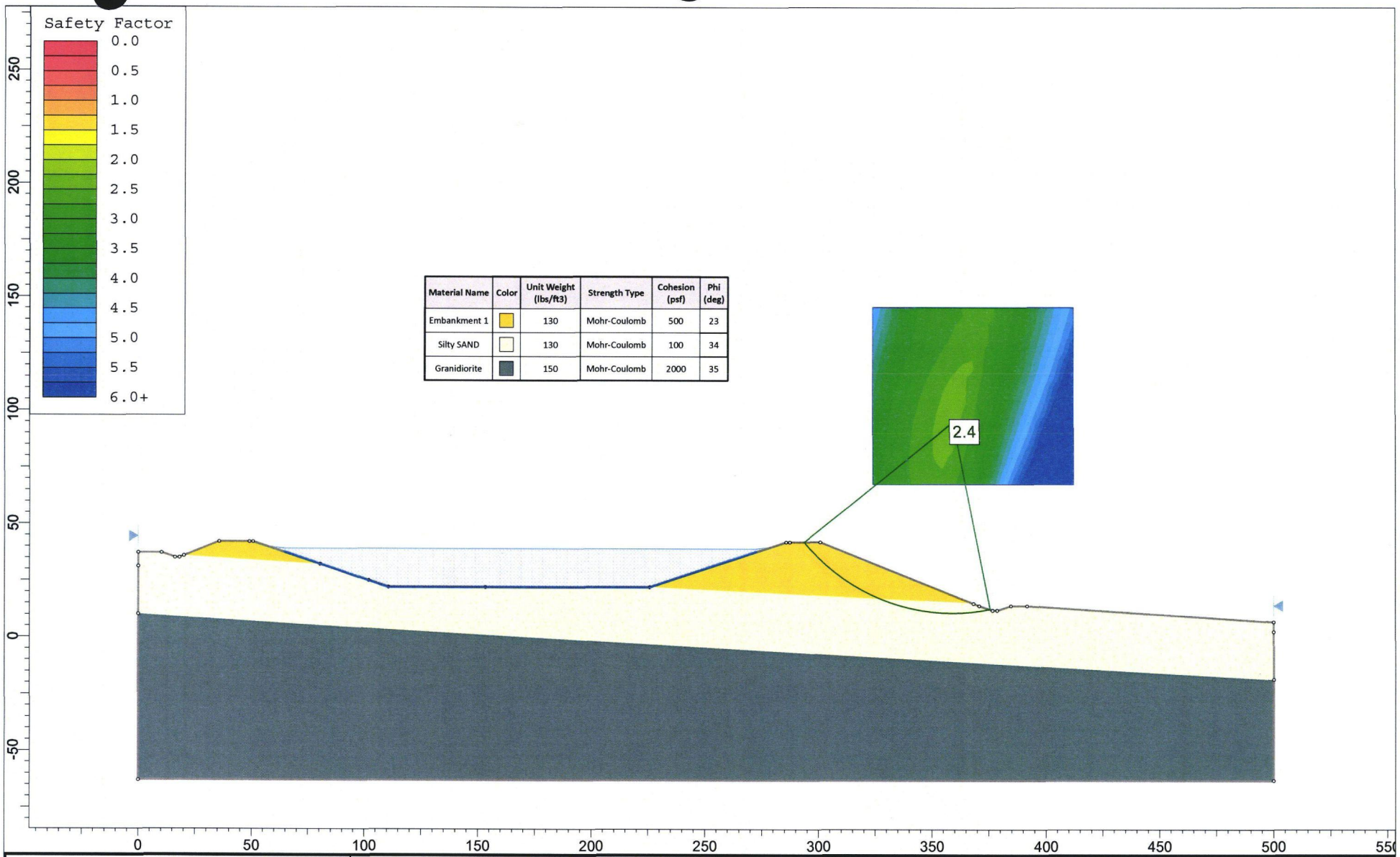
Project: CS Mining
Latitude = 38.48214
Longitude = -113.12016

Number: 01640-002
Date: 1/30/13
By: JMG

S_S =	0.552	(g)	The mapped spectral accleration for short periods [1615.1]
S_1 =	0.165	(g)	The mapped spectral accleration for a 1-second period
Site Class =	C		Table 16.15.1.1
Fa =	1.18		Table 1615.1.2(1)
Fv =	1.64		Table 1615.1.2(2)
S_{MS} =	0.651		S_{MS} = Fa*Ss *The maximum considered E.Q. spectral resonse accelerations
S_{M1} =	0.270		S_{M1} = Fv*S_1 for short and 1-second periods [1615.1.2]
MCE/PGA =	**0.260**		**0.4*S_{MS} [Equation 16-42 in accordance with 1802.2.7 and 1615.2.1]**
S_{DS} =	0.434		S_{DS} = 2/3*S_{MS} *The design spectral response acceleration
S_{D1} =	0.180		S_{D1} = 2/3*S_{M1} at short and 1-second periods
T_0 =	0.083		T_0 = 0.2*S_{D1}/S_{DS}
T_s =	0.414		T_s = S_{D1}/S_{DS}
ΔT =	0.1		Time step for diagram



T (sec)	Sa (g)	Sa (MCE) (g)
0	0.17	0.26
0.08	0.43	0.65
0.41	0.43	0.65
0.51	0.35	0.52
0.61	0.29	0.44
0.71	0.25	0.38
0.81	0.22	0.33
0.91	0.20	0.30
1.01	0.18	0.27
1.11	0.16	0.24
1.21	0.15	0.22
1.31	0.14	0.21
1.41	0.13	0.19
1.51	0.12	0.18
1.61	0.11	0.17
1.71	0.10	0.16
1.81	0.10	0.15
1.91	0.09	0.14



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Embankment 1		130	Mohr-Coulomb	500	23
Silty SAND		130	Mohr-Coulomb	100	34
Granidiorite		150	Mohr-Coulomb	2000	35

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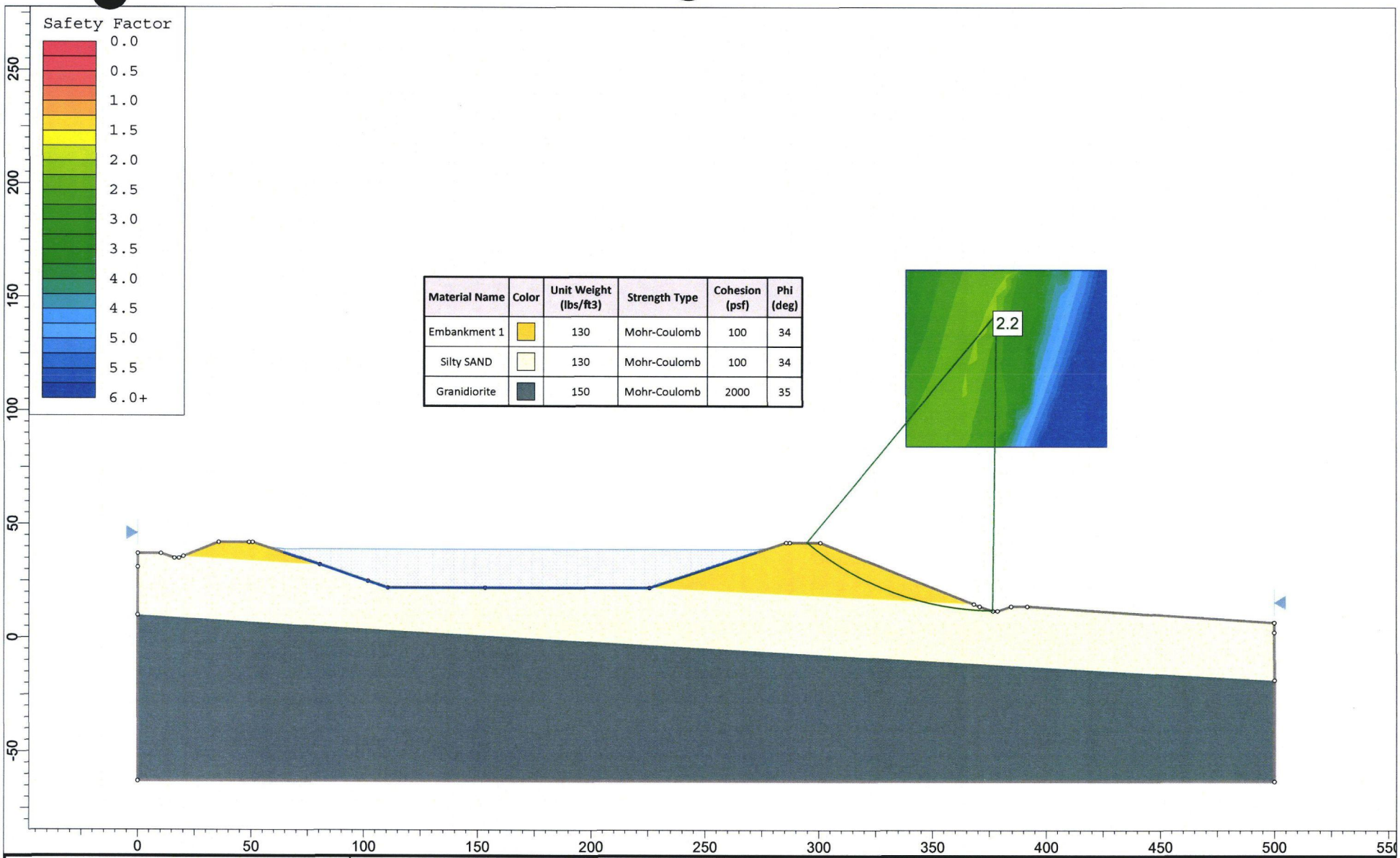
SLIDEINTERPRET 6.027

Project	CS Mining Raffinate and PLS Pond		
Analysis Description	EOC		
Drawn By	JMG	Scale 1:700	Company IGES, Inc
Date	4/7/2014		File Name Raffinate and PLS - EOC.slim



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Embankment 1		130	Mohr-Coulomb	100	34
Silty SAND		130	Mohr-Coulomb	100	34
Granidiorite		150	Mohr-Coulomb	2000	35

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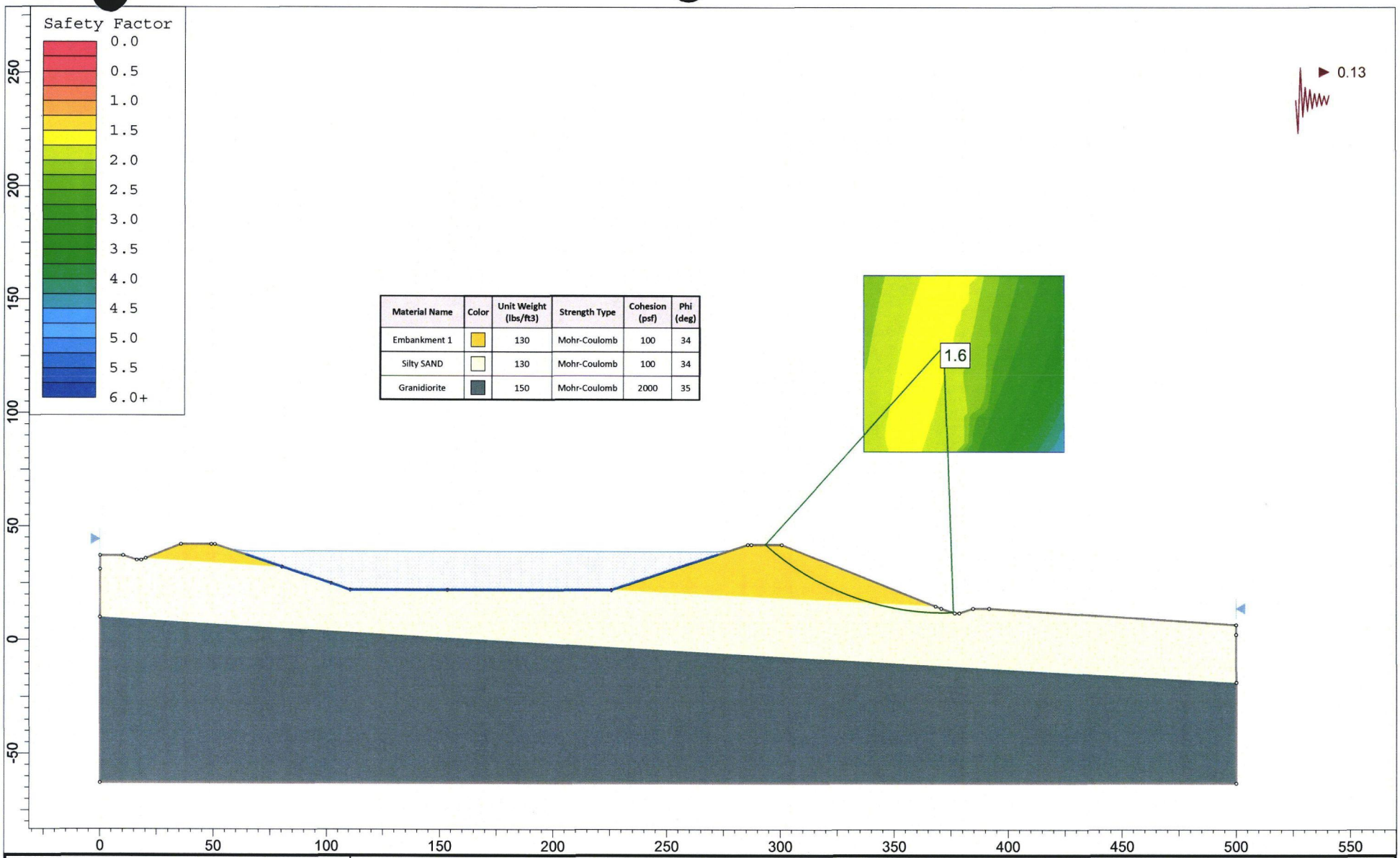
SLIDEINTERPRET 6.027

Project	CS Mining Raffinate and PLS Pond		
Analysis Description	Long Term		
Drawn By JMG	*Scale* 1:700	*Company*	IGES, Inc
Date 4/7/2014		*File Name*	Raffinate and PLS.slim



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Embankment 1		130	Mohr-Coulomb	100	34
Silty SAND		130	Mohr-Coulomb	100	34
Granidiorite		150	Mohr-Coulomb	2000	35

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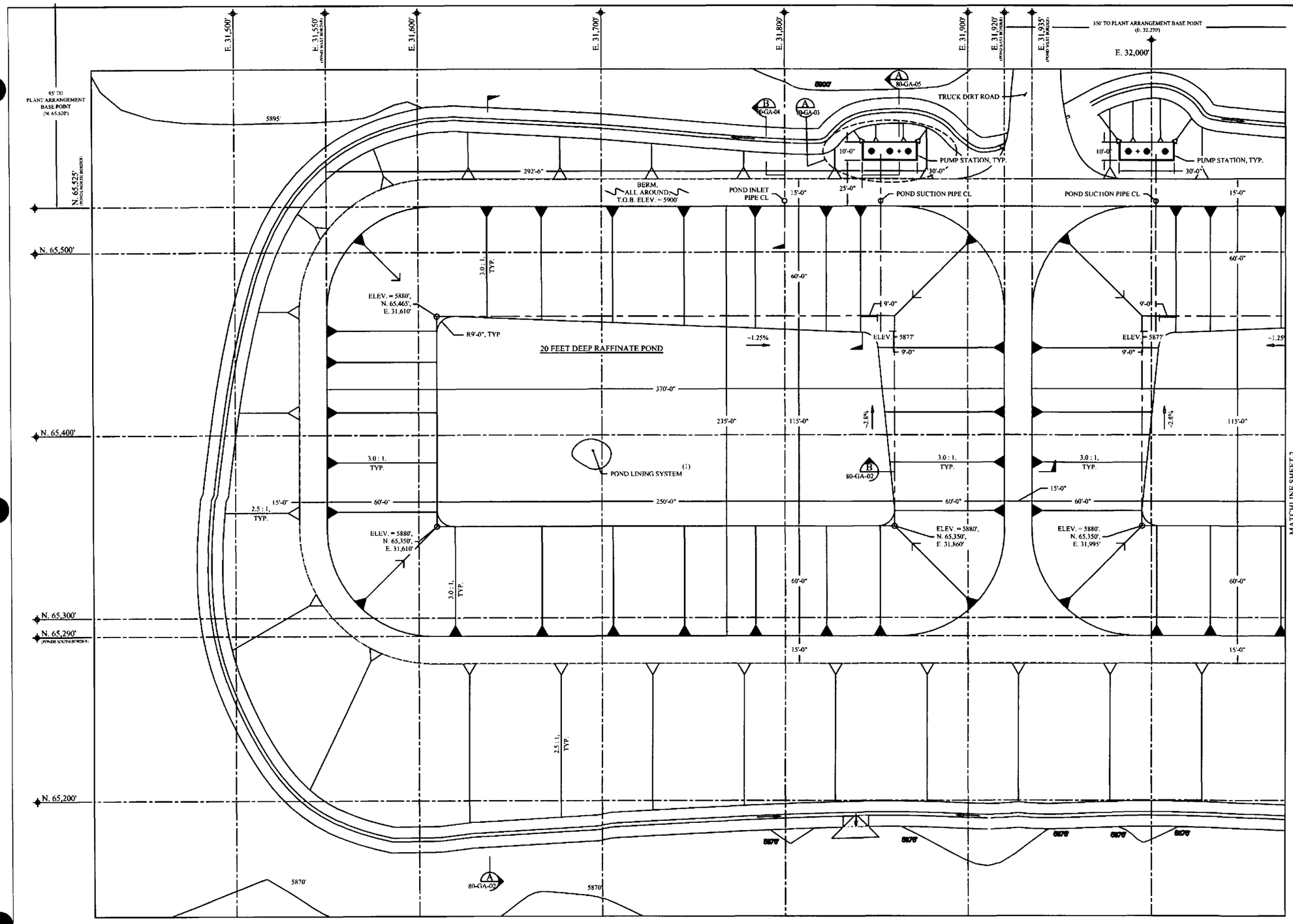
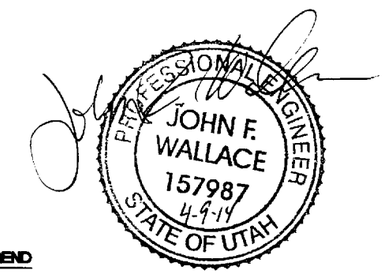
SLIDEINTERPRET 6.027

Project	CS Mining Raffinate and PLS Pond		
Analysis Description	Long Term - Pseudostatic		
Drawn By JMG	*Scale* 1:700	*Company*	IGES, Inc
Date 4/7/2014		*File Name*	Raffinate and PLS - pseudostatic.slim

APPENDIX D





LEGEND

- BERM.
- SWALE.
- SLOPE DIRECTION OF BERM EMBANKMENT TOWARD BOTTOM OF POND/LEAK DETECTION SUMP/CONNECTING TRENCH.
- SLOPE DIRECTION TOWARD NATURAL GROUND.

0 10 20 40 80

SCALE IN FEET

RAFFINATE POND PLAN (A)

SEE SHT-2 FOR EAST PART OF PLS POND LAYOUT.

PROJECT NORTH

MARK		DATE	BY	CHK	MARK		DATE	BY	CHK

REVISIONS | REVISIONS

CONSULTANTS:
IGES®
ideas for a changing world
4153 Commerce Drive
Salt Lake City, Utah
(801) 270-9400
(801) 270-9401 Fax

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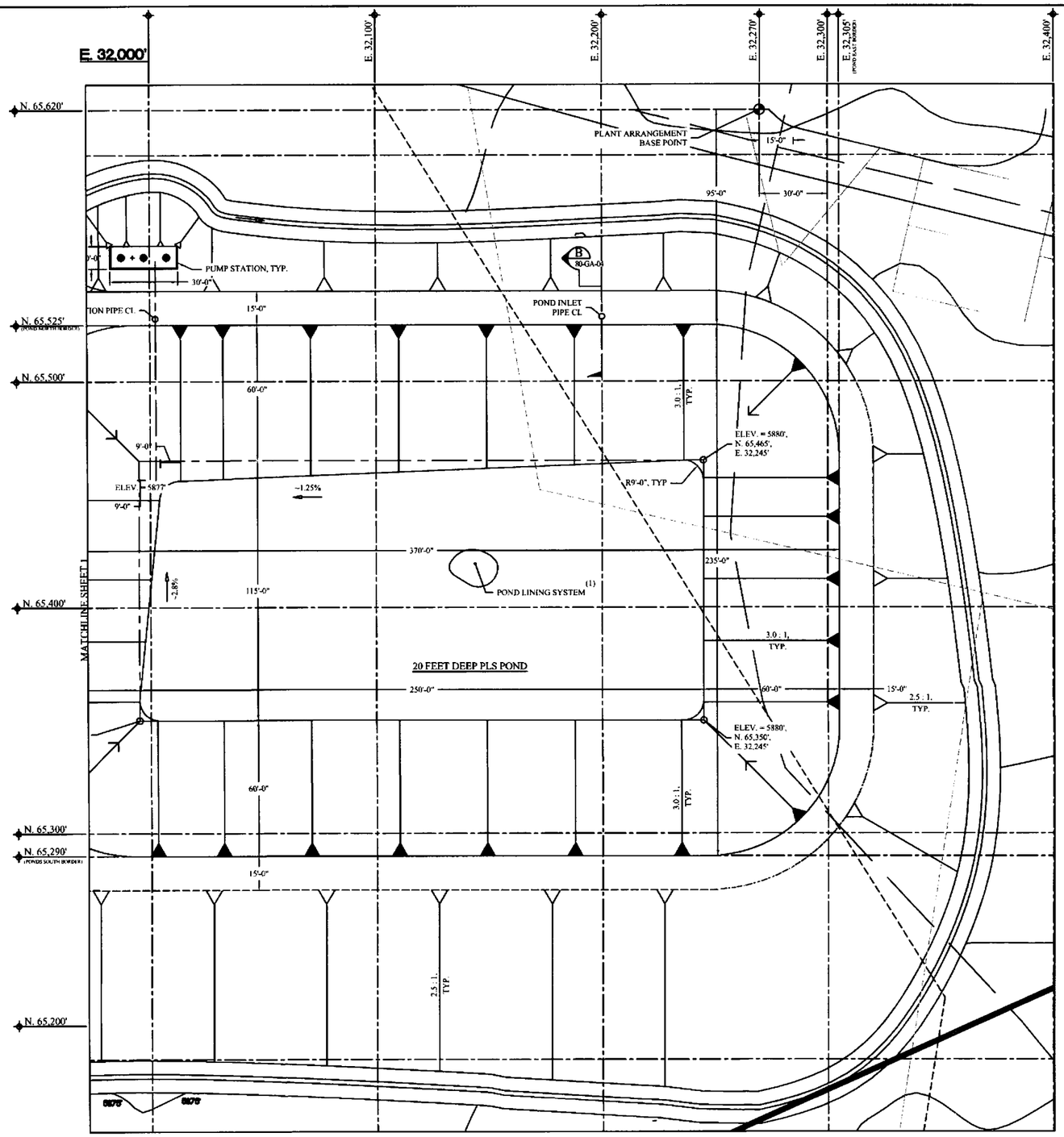
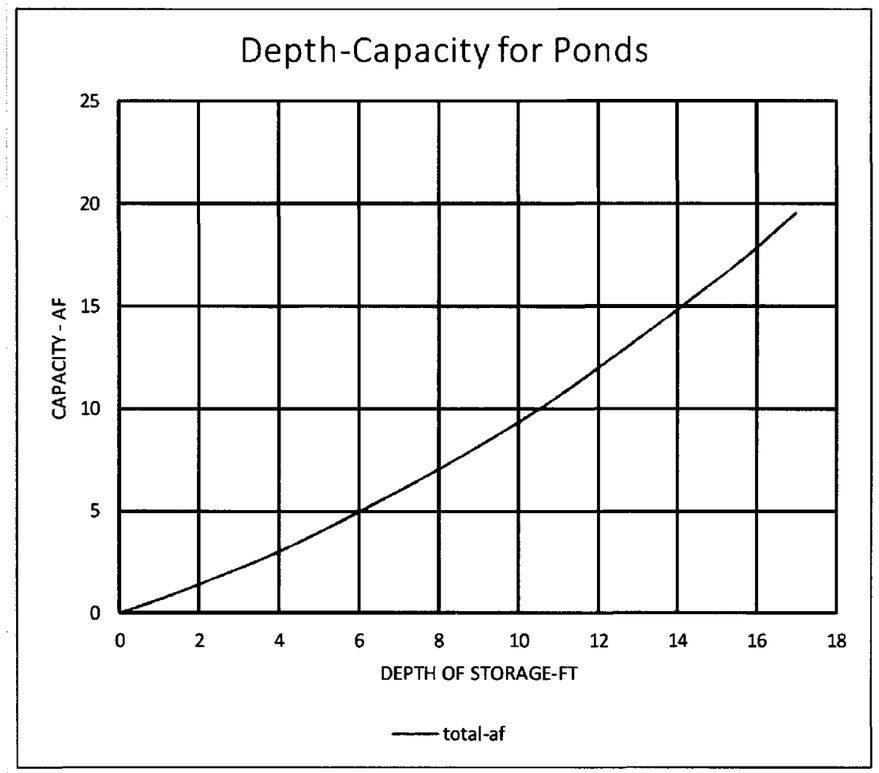
COPPER LEACH/CCD PROJECT - PHASE I
SOLVENT EXTRACTION, ELECTROWINNING
CS MINING
PLS AND RAFFINATE POND LAYOUT

PLOT DATE: 4/04/2014

DESIGNED BY: JPW DATE: 4/02/2014	APPROVED BY: JPW DATE: 4/03/2014		
DRAWN BY: JHG DATE: 4/03/2014	PLOT SCALE 1=1		
CHECKED BY: JPW DATE: 4/04/2014	DWG SCALE AS NOTED		
PROJECT: 01640-002	REVISION NO: 1		
DRAWING NO. 80-GA-01	SHEET 1		





0 10 20 40 80

SCALE IN FEET

PLAN

PROJECT NORTH

SEE SHT-1 FOR WEST PART OF PLS/RAFFINATE POND LAYOUT.

(1) POND LINING SYSTEM:

1st LAYER - 38 mils 8138 XR-5 ETHYLENE INTERPOLYMER ALLOY GEOMEMBRANE,

2nd LAYER - GSE PERMANENT GEONET OR EQUIVALENT,

3rd LAYER - 30 mils 8130 XR-5,

4th LAYER - 8 oz. NON-WOVEN GEOTEXTILE (GSE NW8 OR EQUIVALENT)

PROFESSIONAL ENGINEER
JOHN E. WALLACE
157987
4-9-14
STATE OF UTAH

MARK		DATE	BY	CHK	MARK		DATE	BY	CHK
REVISIONS					REVISIONS				

CONSULTANTS:

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Salt Lake City, Utah
(801) 270-9400
(801) 270-9401 Fax

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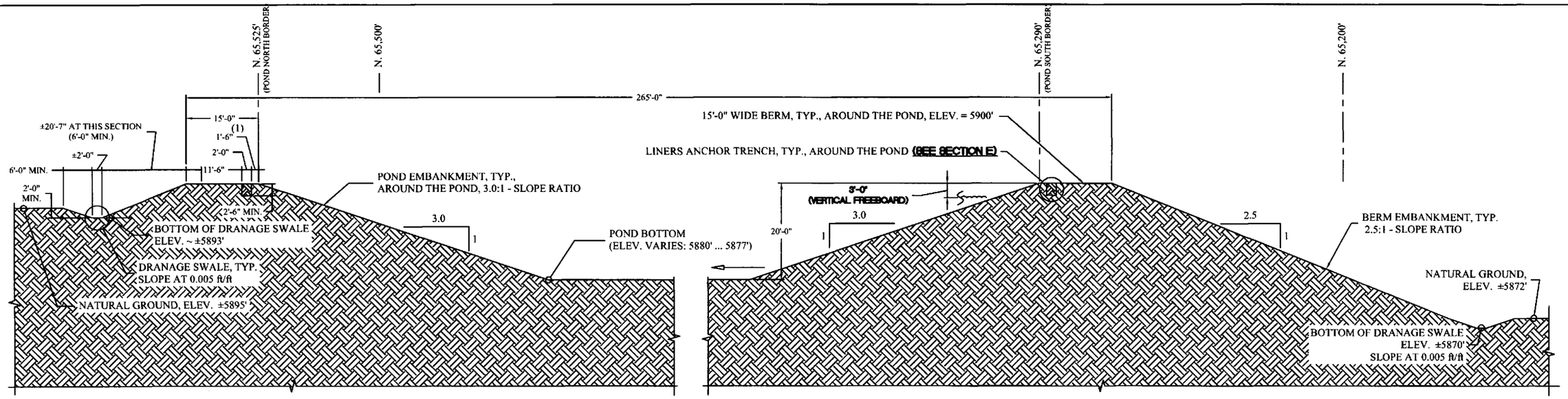
COPPER LEACH/CCD PROJECT - PHASE I
SOLVENT EXTRACTION, ELECTROWINNING
CS MINING
PLS AND RAFFINATE POND LAYOUT

PLOT DATE: 4/04/2014

DESIGNED BY: IPW DATE: 4/02/2014		APPROVED BY: IPW DATE: 4/03/2014	
DRAWN BY: THG DATE: 4/03/2014		PLOT SCALE 1=1	
CHECKED BY: IPW DATE: 4/04/2014		DWG SCALE AS NOTED	
PROJECT: 01640-002		REVISION NO: 1	
DRAWING NO. 80-GA-01		SHEET 2	



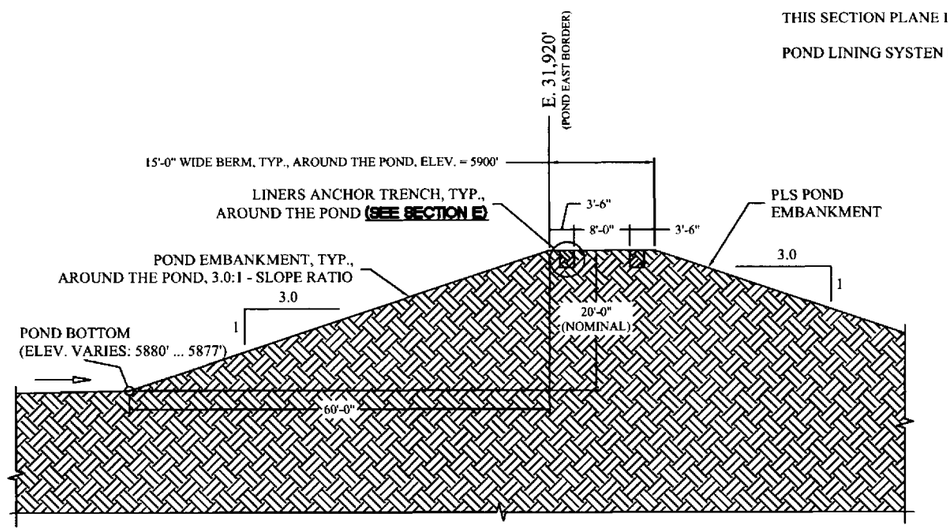
POND SECTION

LOOKING EAST (A) 80-GA-01

0 2.5 5 10 20
SCALE IN FEET

THIS SECTION PLANE IS AT E. ±31,640'. ⟵ - SLOPE OF POND BOTTOM IN NORTH-SOUTH DIRECTION.

POND LINING SYSTEN ISN'T SHOWN. (1) PROVIDE VENTS IN TOP LINER THIS AREA, AROUND THE POND AT INTERVALS PER LINER INSTALLER/MANUFACTURER SPECIFICATIONS.



POND SECTION

LOOKING NORTH (B) 80-GA-01

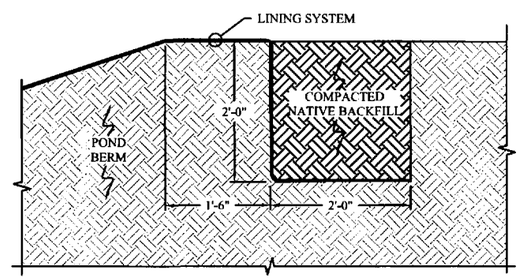
0 2.5 5 10 20
SCALE IN FEET

THIS SECTION PLANE IS AT N. ±65,370'.

POND LINING SYSTEM ISN'T SHOWN.

SEE SECTION A FOR INFORMATION NOT SHOWN.

⟶ - SLOPE OF POND BOTTOM IN EAST-WEST DIRECTION.



LINER ANCHOR TRENCH SECTION (E)

SCALE: 1" = 1'-0"

0 .25 .5 1 2
SCALE IN FEET

PROFESSIONAL ENGINEER
JOHN F. WALLACE
157987
4-9-14
STATE OF UTAH

MARK		DATE	BY	CHK	MARK		DATE	BY	CHK
REVISIONS					REVISIONS				

CONSULTANTS:

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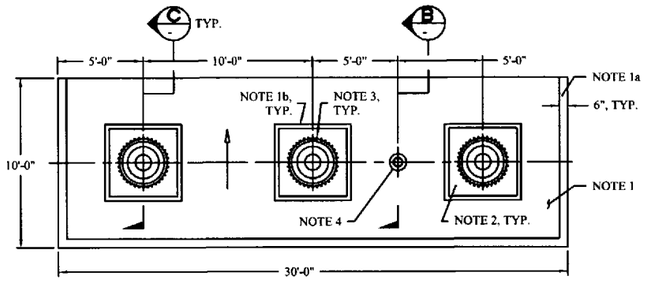
COPPER LEACH/CCD PROJECT - PHASE I
SOLVENT EXTRACTION, ELECTROWINNING
CS MINING
POND SECTION AND DETAILS

PLOT DATE: 4/04/2014

DESIGNED BY: JFW DATE: 4/02/2014		APPROVED BY: JFW DATE: 4/03/2014	
DRAWN BY: JMG DATE: 4/03/2014		PLOT SCALE	1=1
CHECKED BY: JFW DATE: 4/04/2014		DWG SCALE	AS NOTED
PROJECT: 01640-002		REVISION NO:	1
DRAWING NO.		SHEET	
80-GA-02		3	



SURFACE PLAN - PUMP STATION PAD (A) 80-GA-01

PROJECT NORTH

(1) 6" THICK CONCRETE SLAB (T.O.C. ELEV = 5896'-6").

SLAB SLOPE (±1/4" PER FOOT).

(1a) CONCRETE CURB (T.O.C. ELEV = 5897'-3" MAX.)

(1b) PUMP CONCRETE PAD (T.O.C. ELEV = 5896-9").

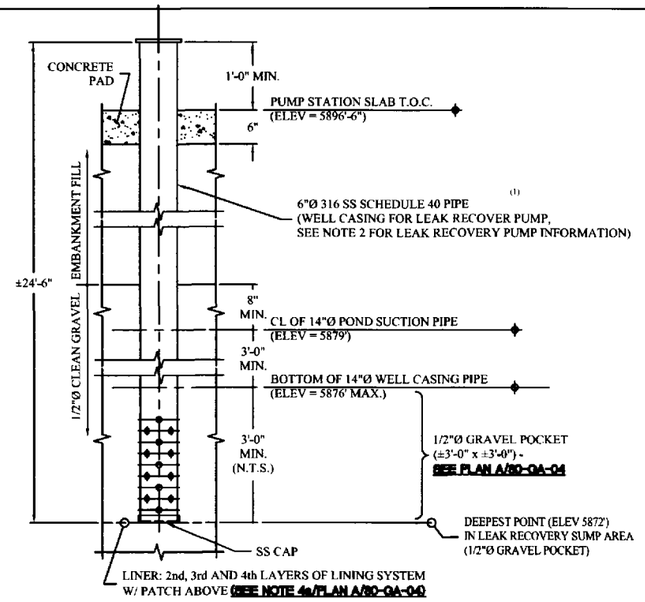
(2) PUMP STEEL SOLE PL (T.O.S. ELEV = 5897'-0").

(3) VERTICAL TURBINE PUMP.

(4) 6"Ø WELL CASING PIPE FOR LEAK RECOVER PUMP.

0 1.25 2.5 5 10

SCALE IN FEET

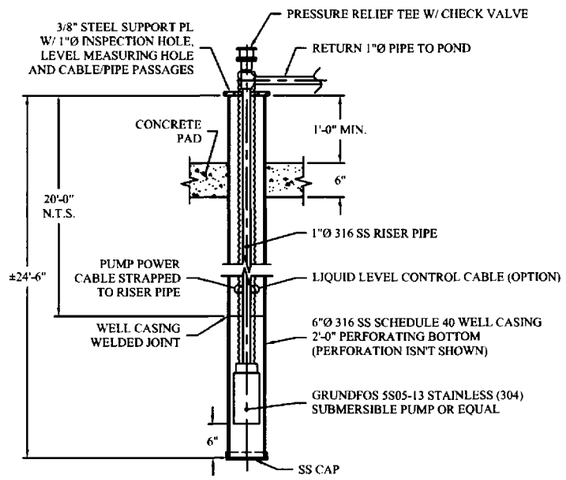


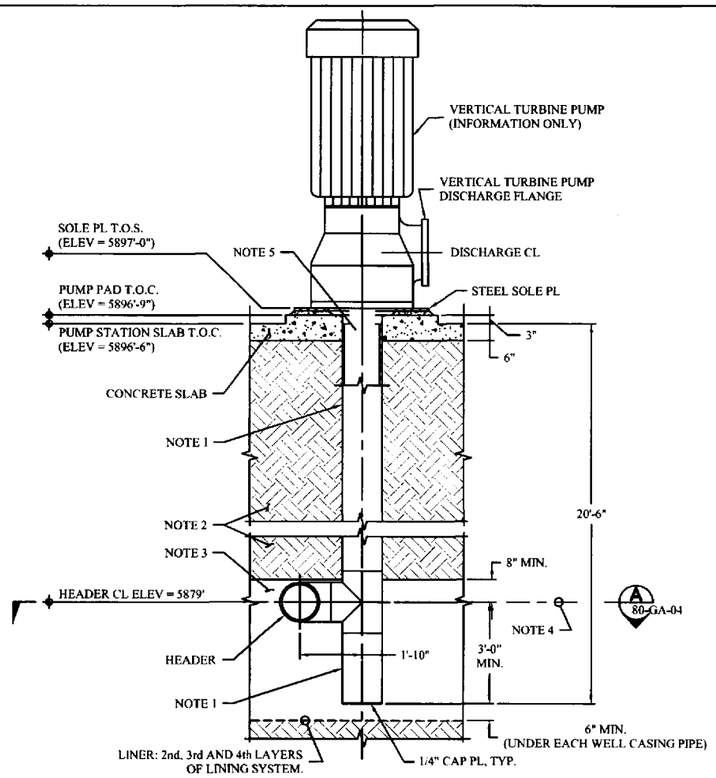
WELL CASING AND LEAK RECOVER PUMP SECTION (B)

LOOKING WEST

(1) PIPE SHALL HAVE WATER-PROOF JOINT W/ CONCRETE SLAB.
PIPE SHALL HAVE 2'-0" PERFORATING BOTTOM:
LAYERS OF 4X EQUALLY SPACED 1"Ø HOLES AT 2" O.C.
HOLES SHALL BE STAGGERED.

(2) LEAK RECOVERY PUMP SCHEMATIC DTL:





WELL CASING FOR SOLUTION RECOVERY SECTION (C)

LOOKING WEST

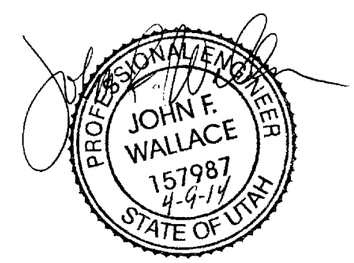
(1) WELL CASING PIPE = 14"Ø STANDARD WEIGHT 316 SS PIPE.
PIPE SHALL HAVE WATER-PROOF JOINT W/ CONCRETE SLAB.

(2) EMBANKMENT FILL.

(3) 1/2"Ø CLEAN GRAVEL.

(4) BOTTOM OF VERTICAL TURBINE PUMPS BOWLS (BOTTOM OF STRAINER).

(5) SHAFT COLUMN ASSEMBLY OF VERTICAL TURBINE PUMP W/ BOWL UNIT AT THE END OF COLUMN ASSEMBLY.



MARK		DATE	BY	CHK	MARK		DATE	BY	CHK
REVISIONS					REVISIONS				

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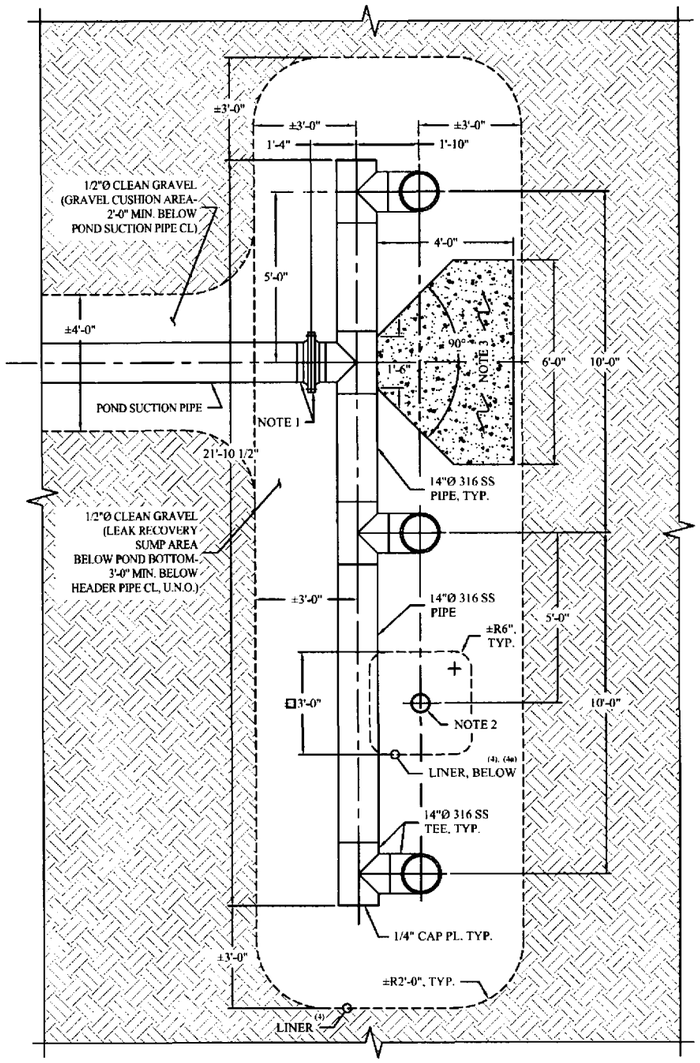
COPPER LEACH/CCD PROJECT - PHASE I
SOLVENT EXTRACTION, ELECTROWINNING
CS MINING
POND SOLUTION/LEAK RECOVERY SECTIONS AND DETAILS

PLOT DATE: 4/04/2014

DESIGNED BY: JPW DATE: 4/03/2014	APPROVED BY: JPW DATE: 4/03/2014		
DRAWN BY: JMG DATE: 4/03/2014	PLOT SCALE: 1=1		
CHECKED BY: JPW DATE: 4/04/2014	DWG SCALE: AS NOTED		
PROJECT: 01640-002	REVISION NO: 1		
DRAWING NO. 80-GA-03	SHEET 4		



LEAK RECOVERY SUMP AND HEADER PLAN (A) 80-GA-03

0 1.25 2.5 5
SCALE IN FEET

PROJECT NORTH

THIS SECTION IS SHOWN AT HEADER ELEV = 5879'.

WELD TEE TO PIPE/FLANGE/CAP PL SHALL BE: V-GROOVE OR BEVEL-GROOVE WELD ALL AROUND W/ 1/8" MIN. PENETRATION AND CONVEX CONTOUR.

(1) FLANGES SHALL BE 14"Ø 316 SS RFWN FLANGES.

(2) 6"Ø 316 SS SCHEDULE 40 WELL CASING PIPE FOR LEAK RECOVER PUMP.

(3) 2'-0" HIGH CONCRETE ANCHOR/THRUST BLOCK.
T.O.C. ELEV SHALL BE 1'-0" ABOVE POND SUCTION PIPE/TEE CL.
CONCRETE SHALL BE: TYPE "V" (3000 psi, 28 DAYS).

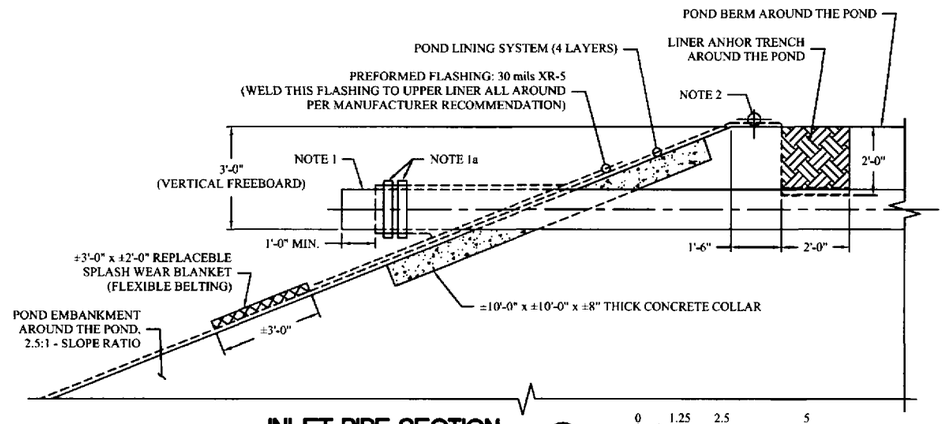
(4) LINER: 2nd, 3rd AND 4th LAYERS OF LINING SYSTEM.

(4a) THIS LINER FORMS GRAVEL POCKET UNDER WELL CASING (LEAK RECOVERY - SEE SECTION B/80-GA-03).
PROVIDE ±3'-0" x 3'-0" x 30 mils XR-5 OR 80 mils HDPE WEAR PATCH AT BOTTOM OF POCKET (ON TOP OF 2nd LAYER OF LINING SYSTEM, DO NOT WELD THIS PATCH TO THIS LINER).

LEAK RECOVERY NOTES:

1. MAX. CAPACITY LEAK RECOVERY SUMP BELOW POND BOTTOM: 320 FT^3 OR 2500 GAL.

2. LEAK RECOVERY WELL SHALL BE EQUIPPED WITH ELECTRIC SUBMERSIBLE PUMP AND 1"Ø RISER PIPE FOR SUMP EVACUATION/LEAK RECOVERY.
DISCHARGE WILL BE MEASURED BY FLOW TOTALIZER.
PUMP TO BE ACTIVATED BY ELECTRIC LEVEL SENSORS OR MANUAL SWITCH FOLLOWING LEVEL SOUNDING OF RECOVERY WELL.



INLET PIPE SECTION (B) 80-GA-01

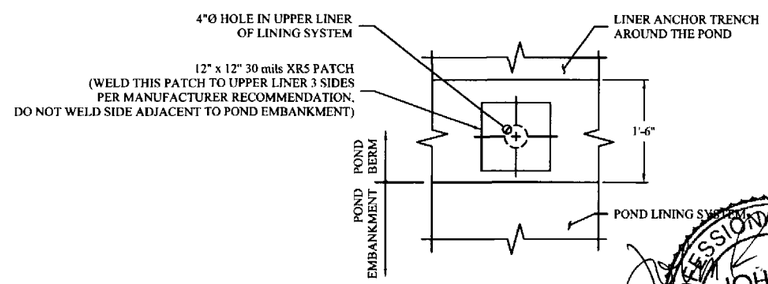
LOOKING WEST

0 1.25 2.5 5
SCALE IN FEET

(1) POND INLET PIPE = 14"Ø STANDARD WEIGHT 316 SS PIPE THROUGH POND BERM.
THIS PIPE SHALL BE CONNECTED W/ 12"Ø HDPE, SCHEDULE 26 PIPE (SEE DWG 80-PI-01).

(1a) SS BANDING, TYP (PIPE BOOT).

(2) PROVIDE VENTS IN UPPER LINER OF LINING SYTEM AT 25'-0" O.C., AROUND THE POND.
SEE SCHEMATIC DTL (DTL SCALE: 1" = 1'-0"):



PROFESSIONAL ENGINEER
JOHN F. WALLACE
157987
4-9-14
STATE OF UTAH

MARK		DATE	BY	CHK	MARK		DATE	BY	CHK
REVISIONS					REVISIONS				

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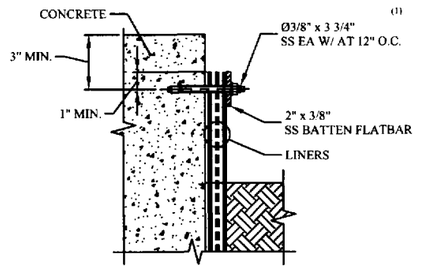
COPPER LEACH/CCD PROJECT - PHASE I
SOLVENT EXTRACTION, ELECTROWINNING
CS MINING
POND SOLUTION/LEAK PLAN AND NOTES

DESIGNED BY: JFW DATE: 4/03/2014		APPROVED BY: JFW DATE: 4/03/2014	PLOT DATE: 4/04/2014
DRAWN BY: JMG DATE: 4/03/2014		PLOT SCALE	1=1
CHECKED BY: JFW DATE: 4/04/2014		DWG SCALE	AS NOTED
PROJECT: 01640-002		REVISION NO:	1
DRAWING NO. 80-GA-04		SHEET 5	



TYPICAL LINER TERMINATION DETAIL (A1)

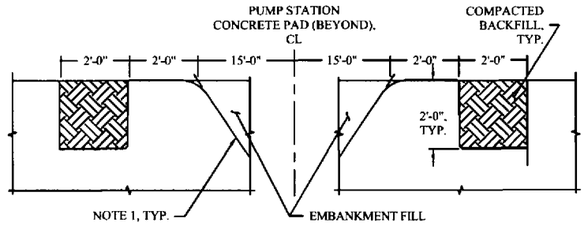
0 .1 .15 0.3 0.6
SCALE IN FEET

CONTRACTOR MAY USE ANOTHER TYPE OF LINER TERMINATION AT OWNER DISCRETION.

EARTH ADJACENT TO CONCRETE TO BE WELL COMPACTED TO PREVENT FUTURE DIFFERENTIAL SETTLEMENT.

CONCRETE TO BE CHAMFERED A MINIMUM OF 1" AT ALL CORNERS IN CONTACT WITH LINER.

(1) PROVIDE NEOPRENE GASKET MATERIAL BETWEEN LINERS AND CONCRETE.



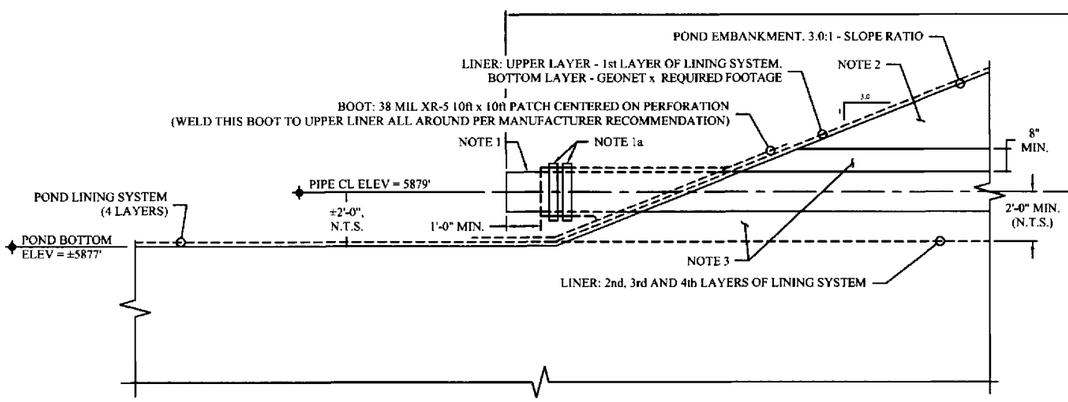
LINER ANCHOR TRENCHES SECTION (A2)

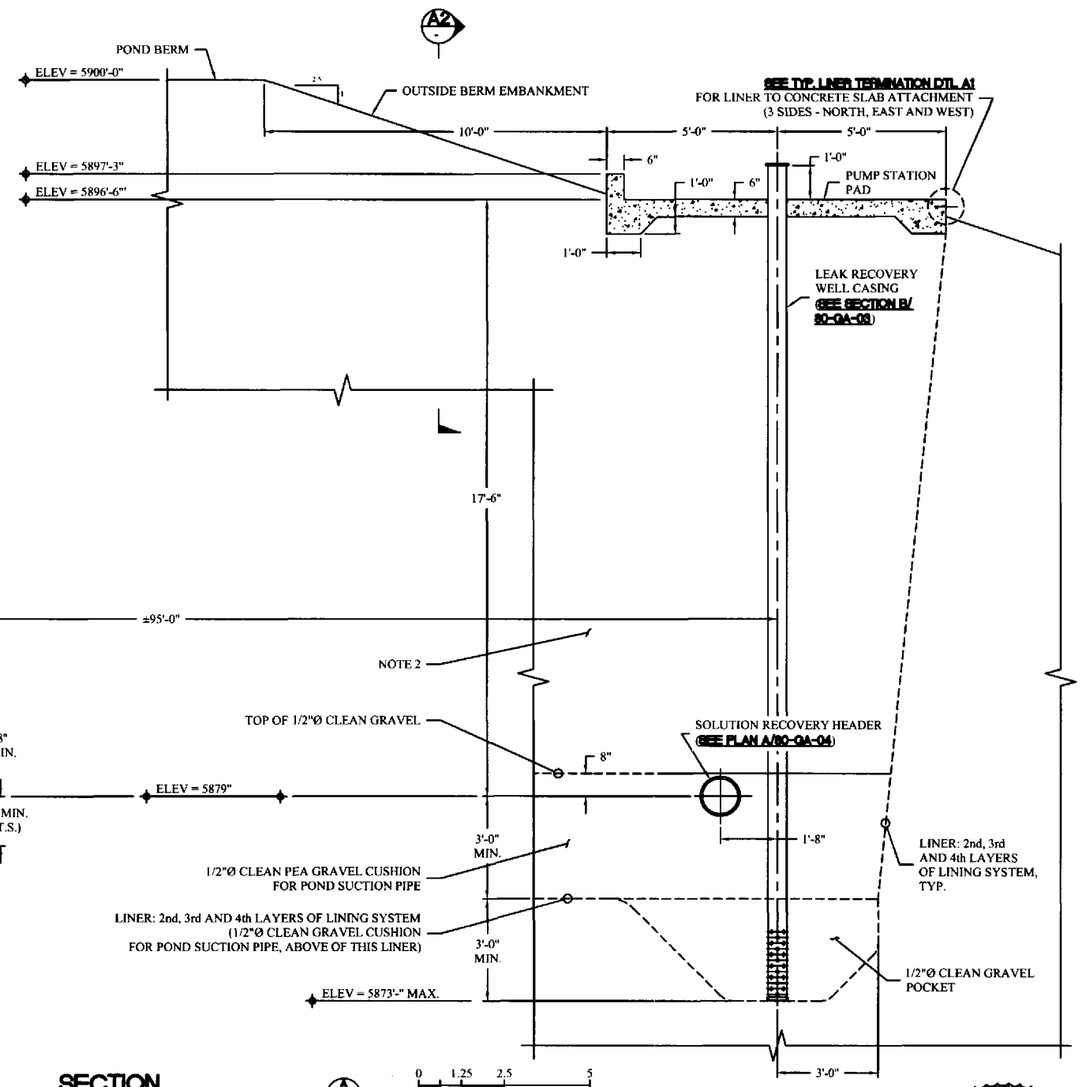
LOOKING NORTH

(1) LINER: 2nd, 3rd AND 4th LAYERS OF LINING SYSTEM.
THIS LINER FORMS ±4'-0" WIDE AT POND SUCTION PIPE ELEV TRENCH FOR 1/2"Ø CLEAN GRAVEL CUSION. BOTTOM OF TRENCH: 3'-0" MIN. BELOW OF PIPE CL. LINER IS ATTACHED TO PUMP STATION CONCRETE PAD BEYOND (SEE DTL A1) AND ANCHORED IN POND LINER ANCHOR TRENCH (NORTH SIDE OF POND).

0 1.25 2.5 5
SCALE IN FEET

SCALE IN FEET





SECTION

LOOKING WEST (A 80-GA-01)

0 1.25 2.5 5
SCALE IN FEET

(1) POND SUCTION PIPE = 14"Ø STANDARD WEIGHT 316 SS PIPE.

(1a) SS BANDING, TYP (PIPE BOOT).

(2) EMBANKMENT FILL.

(3) 1/2"Ø CLEAN PEA GRAVEL (POND SUCTION PIPE CUSHION).

PROFESSIONAL ENGINEER
JOHN F. WALLACE
157987
4-9-14
STATE OF UTAH

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COPPER LEACH/CCD PROJECT - PHASE I
SOLVENT EXTRACTION, ELECTROWINNING
CS MINING
POND SOLUTION/LEAK RECOVERY SECTION AND DETAIL

PLOT DATE: 4/04/2014

DESIGNED BY: JFW DATE: 4/03/2014	APPROVED BY: JFW DATE: 4/03/2014		
DRAWN BY: JNG DATE: 4/03/2014	PLOT SCALE 1=1		
CHECKED BY: JFW DATE: 4/04/2014	DWG SCALE AS NOTED		
PROJECT: 01640-002	REVISION NO: 1		
DRAWING NO. 80-GA-05	SHEET 6		

APPENDIX E

TECHNICAL SPECIFICATIONS

For

PHASE 1 EMBANKMENT RAISE
CS MINING

Division 1 – General Requirements

SECTION	01011	Summary of Project
	01039	Project Coordination and Meetings
	01300	Submittals
	01500	Temporary Controls
	01600	Materials, Labor and Equipment
	01700	Contract Closeout

Division 2 – Site Work

SECTION	02200	Site Preparation
	02300	Earthwork
	02400	Subgrade Preparations
	02714	Geotextile Fabric
	02715	Geonet Drainage Layer
	02771	XR-5 Liner

DIVISION 1 - GENERAL REQUIREMENTS

SECTION 01011

SUMMARY OF PROJECT

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Work included

B Summary of Work

1.2 RELATED SECTIONS

A. Section 01039 – Project Coordination and Meetings

B. Section 01300 – Submittals

C. Section 01500 – Temporary Controls

D. Section 01600 – Materials, Labor and Equipment

E. Section 01700 – Contract Closeout

1.3 WORK INCLUDED

A. Construction of TWO (2) lined impoundments approximately 2.2 acres in planned dimension each. Work includes: clearing and grubbing; topsoil removal and stockpiling; excavation of side slopes; fill placement for embankment construction; anchor trench construction,; placement of XR-5 liner system and drain net leak detection, installation of fluid pump station and installation of leak detection sump, monitoring and removal system.

Final subgrade preparation and certification of base soil for placement of XR-5 liner system.

Furnish and install approximately 210,000 square feet each of 30 mil XR-5, 38 mil XR-5, drain net and geotextile cushion to form the double lined system with leak detection.

1.4 SUMMARY OF WORK

A. The construction of the ponds will be performed in conjunction with development of the SX/EW plant being added to the existing mill and flotation operations. CONTRACTOR to perform the following work:

- Submit Health and Safety Plan to OWNER for review and approval
- Submit Construction Schedule to OWNER for review and approval
- Submit Earthmoving Plan to OWNER for review and approval

B. Clear and grub all vegetation from the proposed pond site. Remove and stockpile at a minimum the uppermost 6" of soil seamed "topsoil" for eventual use in site reclamation. Excavate from the interior of the pond fill materials to be used for perimeter embankment construction to the plans and grades shown on the drawings.

C. Perform final subgrade preparation for placement of XR-5 liner system. Preparation of subgrade includes mass excavation and mass fill operations including compaction of fill soil. CONTRACTOR is required to certify, in writing (subgrade acceptance form), that the subgrade soil is adequate for the installation of liner materials prior to placement of liner system.

D. Furnish and install 30-mil and 38-mil XR-5 liner materials, drain net and non-woven geotextile as detailed on the construction drawings. Drawings included with the bid package are for bidding purposes only. Final locations and final details will be confirmed with the issue of construction drawings prior to work commencing. Quantities are not expected to change more than ten percent (10%) from bidding documents to construction documents.

E. All products are to be installed or placed in accordance with standards required by respective manufacturer.

F. Anchor geomembranes, drain net, and geotextile securely in place to prevent the movement of installed materials. Anchoring of all materials shall be performed with anchor trenches or other ENGINEER approved methods.

G. Sequence installation to ensure that all operations are achieved in an orderly and expeditious manner.

H. Touch-up minor damaged surfaces caused during delivery, storage, handling and installation. Replace damaged components as necessary.

I. Installation will not be considered complete until the liner and other materials are completely inspected by the QA Inspector.

1.5 DEFINITIONS

A. CONTRACTOR, The term "CONTRACTOR" shall be used to describe the various work

activities of both the prime CONTRACTOR and all of the Subcontractors for which the CONTRACTOR retains responsibility.

B. ENGINEER, the term "ENGINEER" shall be used to describe the design ENGINEER responsible for the structural design of the starter dam, site preparation and subgrade recommendations, liner system, and the specifications therein.

C. OWNER, the term "OWNER" shall be used in the specifications herein to describe CS Mining and its affiliates.

PART 1 PRODUCTS

Not Used.

PART 2 EXECUTION

Not Used.

END OF SECTION

SECTION 01039

PROJECT COORDINATION AND MEETINGS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Prime CONTRACTOR Responsibilities

B. Preconstruction Meeting

C. Daily Meetings

D. Weekly Meetings

E. Work Deficiency Meetings

1.2 RELATED SECTIONS

A. Section 01011 – Summary of Project

B. Section 01300 – Submittals

C. Section 01500 – Temporary Controls

D. Section 01600 – Materials, Labor and Equipment

E. Section 01700 – Contract Closeout

1.3 PRIME CONTRACTOR RESPONSIBILITY

A. Coordination

1. The prime CONTRACTOR shall properly coordinate all work. Expediting the work of the various trades as necessary so that the different elements are built and installed in proper sequence. All parts shall fit together in a neat, tight, and professional manner and function properly and as intended at completion of the work without interruption of the current or future operations.

2. The CONTRACTOR shall see to it that orders for manufactured items, which he is to furnish as called for under this contract and specifications and under his direction, are ordered by the various trades involved and are delivered to the site at the proper time.

3. The CONTRACTOR and the various trades working under his leadership and direction shall coordinate their work with adjacent work and with other trades so as to facilitate the general progress of the work. Each trade shall afford other trades every reasonable opportunity for the installation of their work and for the storage of their material.

B. Conformity with Plans

1. The CONTRACTOR shall perform all work in conformity with the drawings, specifications, QA/QC Plan and instructions from the ENGINEER.

2. All minor details of the work, which are not specifically mentioned in the specifications, but are obviously incidental, shall be considered a part of the work for which prices are given in the proposal, and no extra compensation shall be allowed the CONTRACTOR for the performance thereof.

C. Errors and Omissions

1. If the CONTRACTOR, in the course of the work, finds any errors or omissions in plans or in the layout as given by survey points and instructions, or if he finds any discrepancy between the plans and the physical conditions of the locality, he shall promptly verify the same and notify the OWNER. Any work done after such discovery, until authorized, will be done at the CONTRACTOR's risk.

D. Notice to OWNER

1. The CONTRACTOR shall give forty-eight hours notice when he will need the services of the OWNER for staking out any portion of the work.

E. Lines and Grades

1. All work shall be done to the true line and grade, as indicated by the Drawings.

2. The OWNER will furnish initial survey control points and the CONTRACTOR must protect them and will be held responsible for any defective work caused by his negligence in this respect.

3. If the survey control points are destroyed or if additional points are needed, the OWNER will furnish them to the CONTRACTOR, and the CONTRACTOR shall reimburse the OWNER for the additional expense of reestablishing the survey control points.

F. Supervisory Personnel

1. It is the intent of these specifications to provide a completed project, which will in every way reflects the work of competent journeymen in the various trades represented.

2. The CONTRACTOR shall insure that each portion of the work is supervised by a qualified person, well versed in the operation of the various tools required for the trade, the method in which the work is to be done, and knowledge of the general requirements of the construction

work.

3. All work is to be done in accordance with the latest methods devised for such work to insure a professional appearance of the completed project.

1.4 MEETINGS

A. A Preconstruction Meeting will be held with OWNER, ENGINEER, QA Personnel, and all CONTRACTORS and their QC Personnel to facilitate project schedule and coordination. CONTRACTOR shall submit preliminary schedule at Preconstruction meeting and provide weekly updates as work progresses. The State of Utah Division of Water Quality (DWQ) personnel may attend the Preconstruction meeting at their option. The meeting will be documented by the QA Inspector or ENGINEER on a Meeting Documentation form.

B. A Daily Progress Meeting will be held with attendance required by the CONTRACTOR, the QC Inspector, and the QA Inspector. The meeting will be documented by the QA Inspector on a Meeting Documentation form. The purpose of the meeting will be to:

- Review the previous day's work
- Review the work location and activities
- Discuss any problems

C. A Weekly Progress meeting will be held with attendance required by the CONTRACTOR, the QC Inspector, the QA Inspector, and OWNER. The ENGINEER and State of Utah DWQ personnel may attend at their option. The meeting will be documented by the QA Inspector on a Meeting Documentation form. The purpose of the meeting will be to:

- Review minutes of previous meetings.
- Review of Work progress and updated schedule.
- Field observations, problems, and decisions.
- Identification of problems that impede planned progress.
- Review of submittals schedule and status of submittals.
- Review of off-site fabrication and delivery schedules.
- Maintenance of progress schedule.
- Corrective measures to regain projected schedules.
- Planned progress during succeeding work period.
- Coordination of projected progress.
- Maintenance of quality and work standards.
- Effect of proposed changes on progress schedule and coordination.
- Other business relating to Work.

D. A Work Deficiency Meeting will be held if or when any work items are identified to be deficient. Attendance will be required by the CONTRACTOR, the QC Inspector, the QA Inspector, ENGINEER, and OWNER. The meeting will be documented by the QA Inspector on a Meeting Documentation form. The State of Utah DWQ personnel may attend at their option. The purpose of the meeting will be to:

- Review the Problem Identification/Corrective Measures Reports
- Review the Corrective Action Items
- Discuss any problems

PART 3 PRODUCTS

Not Used.

PART 4 EXECUTION

Not Used.

END OF SECTION

SECTION 01300

SUBMITTALS

PART 1 - GENERAL

1.1 SECTION INCLUDES A.

Submittal Procedures B.

Proposed Products List C.

Product Data

D. Certificates

E. Manufacturer's Instructions

1.2 RELATED SECTIONS

A. Section 01011 – Summary of Project

B. Section 01039 – Project Coordination and Meetings

C. Section 01500 – Temporary Controls

D. Section 01600 – Materials, Labor and Equipment

E. Section 01700 – Contract Closeout

1.3 SUBMITTAL PROCEDURES

A. Collect submittals from all manufacturers or suppliers and provide to ENGINEER for written approval of products.

B. Identify manufacturer or supplier and reference appropriate drawing and/or specification location.

C. Identify variations from Contract Documents and Product or system limitations that may be detrimental to successful performance of the completed Work.

D. Obtain written approval of materials from ENGINEER prior to ordering from vendor.

E. When revised for resubmission, identify all changes made since previous submission.

F. Distribute copies of reviewed submittals as appropriate. Instruct parties to promptly report any inability to comply with requirements.

1.4 PROPOSED PRODUCTS LIST

A. Within 15 days after date of Notice to Proceed, submit list of major products proposed for use, with name of manufacturer, trade name and model number of each product.

B. For products specified only by reference standards, give manufacturer, trade name, model or catalog designation, and reference standards.

1.5 PRODUCT DATA

A. Product Data For Review:

1. Submitted to ENGINEER for review for the limited purpose of checking for conformance with Plans and Specifications

B. Submit one copy to OWNER.

C. Mark copy to identify applicable products, models, options, and other data. Supplement manufacturers' standard data to provide information specific to this project.

1.6 CERTIFICATES

A. When specified in individual specification sections, submit certification by the manufacturer, installation/application Subcontractor, to the ENGINEER.

B. Indicate material or product conforms to or exceeds specified requirements. Submit supporting reference data, affidavits, and certifications as appropriate.

C. Certificates may include recent or previous test results on material or Product, but must be acceptable to ENGINEER.

1.7 MANUFACTURER'S INSTRUCTIONS

A. When specified in individual specification sections, submit printed instructions for delivery, storage, installation and maintenance to CONTRACTOR and ENGINEER. ENGINEER will forward instructions to QA personnel.

B. Indicate special procedures, perimeter conditions requiring special attention, and special environmental criteria required for application or installation.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

Not Used.

END OF SECTION

SECTION 01500

TEMPORARY CONTROLS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Site Safety

1.2 RELATED SECTIONS

A. Section 01011 – Summary of Project

B. Section 01039 – Project Coordination and Meetings

C. Section 01300 – Submittals

D. Section 01600 – Materials, Labor and Equipment

E. Section 01700 – Contract Closeout

1.3 SITE SAFETY

A. The CONTRACTOR shall ensure that proper care is exercised to make the work safe at all times.

1. Materials, equipment or other obstructions shall not be strung or placed on or in any traveled roadways in a manner that will be hazardous to vehicles or personnel and shall provide and maintain at all times, and as directed by the OWNER for the protection of all traffic operating in work areas.

2. If in the operation of equipment it becomes necessary to encroach upon the above mentioned traveled roadway or at any point that may be construed by the OWNER as dangerous to traffic or personnel, the CONTRACTOR shall place guards, at his expense, to direct and inform site persons of existing danger.

B. The CONTRACTOR shall be held responsible for any costs or schedule impacts through mishaps or accidents caused by his neglect or the neglect of any of his employees or agents in the performance of the work involved in the handling of this project work. No additional costs will be allowed by the OWNER for this added protection.

C. The CONTRACTOR shall make all workers aware of processes and procedures involved in the work that may present a health hazard to workers prior to beginning work in accordance with MSHA standards.

PART 2 – PRODUCTS

Not Used

PART 3 – EXECUTION

Not Used

END OF SECTION

SECTION 01600

MATERIALS, LABOR AND EQUIPMENT

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. CONTRACTOR Provided Materials, Labor and Equipment

1.2 RELATED SECTIONS

A. Section 01011 – Summary of Project

B. Section 01039 – Project Coordination and Meetings

C. Section 01300 – Submittals

D. Section 01500 – Temporary Controls

E. Section 01700 – Contract Closeout

1.3 CONTRACTOR PROVIDED MATERIALS, LABOR AND EQUIPMENT

A. The CONTRACTOR shall furnish all labor, materials, equipment, tools, supervision, etc., and all costs involved, necessary to complete the work required under this contract as specified, including all power required to power all tools and equipment used, such as gasoline, fuel, oil, electricity, etc.

B. All equipment, tools, machinery, etc. used shall be in good repair and shall be maintained in a good workable and safe condition necessary to continuously carry on the work involved in this project in a professional, expeditious and safe manner, without serious or costly delays in the performance of all phases of the work involved.

C. Use of any and all equipment and machinery on this project shall be in accordance with all applicable MSHA standards.

D. No equipment or machinery shall be operated in or over paved streets or prepared roadway shoulders, in getting to, from or in working on this project that is equipped with treads or cleats that, in the opinion of the OWNER, may be injurious to pavement or shoulder surfaces.

E. Any damage done under these circumstances shall be immediately repaired by the CONTRACTOR at the CONTRACTOR's expense.

F. If requested by the OWNER or the ENGINEER, the CONTRACTOR shall furnish a list of all equipment and machinery that he has of his own or that he has access to, which he proposes to

use for this project. The CONTRACTOR shall state the present condition of equipment as to its fitness and safety on this type of work, together with a written statement as to the past experiences of those who will operate the various machines to be used, their qualifications and the previous experiences the CONTRACTOR has had in performing similar work as that required under this contract.

PART 2 – PRODUCTS

Not Used

PART 3 – EXECUTION

Not Used

END OF SECTION

SECTION 01700

CONTRACT CLOSEOUT

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Closeout procedures.

B. Final cleaning.

C. Project record documents.

D. Warranties and bonds.

1.2 RELATED SECTIONS

A. Section 01011 – Summary of Project

B. Section 01039 – Project Coordination and Meetings

C. Section 01300 – Submittals

D. Section 01500 – Temporary Controls

E. Section 01600 – Materials, Labor and Equipment

1.3 CLOSOUT PROCEDURES

A. Submit written certification that Contract Documents have been reviewed, Work has been inspected, and that Work is complete in accordance with Contract Documents and ready for OWNER and ENGINEER's review.

B. Provide to OWNER all Project Record Documents.

C. Submit final Application for Payment identifying total adjusted Contract Sum, previous payments, and sum remaining due.

1.4 FINAL CLEANING

A. Execute final cleaning prior to final project assessment.

B. Remove waste and surplus materials, rubbish, and construction facilities from the site.

1.5 PROJECT RECORD DOCUMENTS

A. Maintain on site one set of the following record documents; record actual revisions to the Work:

1. Drawings.
2. Specifications.
3. Addendums.
4. Change Orders and other modifications to the Contract.
5. Product Data, and Samples.
6. Manufacturer's instruction for installation, and repairing.
7. All documents specified in the project QA/QC Plan.

B. Ensure entries are complete and accurate, enabling future reference by OWNER.

C. Store record documents separate from documents used for construction.

D. Record information concurrent with construction progress.

E. Specifications: Legibly mark and record at each product section, a description of actual Products installed, including the following:

1. Manufacturer's name and product model and number.
2. Product substitutions or alternates utilized.
3. Changes made by Addenda and modifications.

F. Record Drawings [and Shop Drawings]: Legibly mark each item to record actual construction including:

1. Measured horizontal and vertical locations of underground installations, referenced to permanent surface improvements.
2. Field changes of dimension and detail.
3. Details not on original Contract drawings.

G. Submit documents to OWNER with claim for final Application for Payment

1.6 WARRANTIES AND BONDS

A. Provide notarized copies.

B. Execute and assemble transferable warranty documents from Subcontractors, suppliers, and manufacturers.

C. Provide Table of Contents and assemble in ring binder with durable cover.

D. Submit prior to final Application for Payment.

E. For items of Work delayed beyond date of Substantial Completion, provide updated submittal within 10 days after acceptance, listing date of acceptance as start of warranty period.

PART 2 – PRODUCTS

Not Used.

PART 3 – EXECUTION

Not Used.

END OF SECTION

DIVISION 2 – SITE WORK

SECTION 02200

SITE PREPARATION

PART 1 – GENERAL

1.1 SECTION INCLUDES

A. Clearing, grubbing, and stripping project site.

1.2 RELATED SECTIONS

A. Section 02300 – Earthwork

B. Section 02400 – Subgrade Preparation

C. Section 02714 – Geotextile Fabric

D. Section 02715 – Geonet Drainage Layer

E. Section 02771 – XR-5 Liner

1.3 DEFINITIONS

A. Clearing: Consists of removal of natural obstructions and existing foundations, buildings, fences, lumber, walls, stumps, brush, weeds, rubbish, trees, boulders, utility lines, and any other items which interferes with construction operations or are designated for removal.

B. Grubbing: Consists of the removal and disposal of wood or root matter below the ground surface remaining after clearing and includes stumps, trunks, roots, or root systems greater than 1 inch in diameter or thickness to a depth of 6 inches below the ground surface.

C. Stripping: Includes the removal and disposal of all organic sod, topsoil, grass and grass roots, and other objectionable material remaining after clearing and grubbing from the areas designated to be stripped. The depth of stripping is estimated to be a minimum of 6 inches, but the required depth of stripping will be determined by the ENGINEER.

1.4 QUALITY ASSURANCE

A. Regulatory requirements: Verify and comply with applicable regulations

regarding those governing noise, dust, nuisance, drainage and runoff, fire protection, and disposal.

B. Pre-construction meeting: Meet with ENGINEER to discuss order and method of work.

1.5 PROJECT CONDITIONS

A. Existing conditions:
   1. Verify character and amount of clay, sand, gravel, quicksand, water, rock, hardpan, and other material involved and work to be performed.

1.6 SEQUENCING AND SCHEDULING

A. Clearing and grubbing: Perform clearing and grubbing in advance of grading operations.

PART 2 – PRODUCTS

Not Used.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Verification of conditions: Examine site and verify existing conditions before beginning work.

3.2 PREPARATION

A. Protect existing improvements from damage by site preparation work.

3.3 INSTALLATION

A. Clearing:
   1. Clear areas where construction is to be performed, including borrow areas and other areas as indicated on the Drawings, or specified in this Section, of topsoil, stumps, brush, roots, weeds, trees, shrubs, rubbish, and other objectionable material of any kind which, if left in place, would interfere with proper performance or completion of the work, would impair its subsequent use, or form obstructions. Borrow area topsoil shall be stockpiled in an area designated by the OWNER.
   2. It is the CONTRACTOR's responsibility to determine the effort needed to remove shrubs, brush, rocks, and objectionable materials required for construction activities.
   3. Do not incorporate organic material from clearing and grubbing operations in fills and backfills.

4. CONTRACTOR's construction facilities: Fill or remove pits, fill, and other earthwork required for erection of facilities, upon completion of the work, and level to meet existing contours of adjacent ground.

B. Grubbing:

1. From excavated areas: Grub stumps, roots, and other obstructions 3 inches or over in diameter to depth of not less than 18 inches below finish grade.
2. In embankment areas or other areas to be cleared outside construction area: Do not leave stumps, roots, and other obstructions higher than the following requirements:

Height of Embankment over Stump	Depth of Clearing and Grubbing
0 feet to 2 feet	Grub stumps or roots 3 inches or over in diameter to 18 inches below original grade. Cut others flush with ground.
2 feet to 3 feet	Grub stumps 1 foot and over in diameter to 18 inches below original grade. Cut others flush with ground.
Over 3 feet	Leave no stumps higher than stump top diameter, and in no case more than 18 inches.

3. Backfill and compact cavities left below subgrade elevation by removal of stumps or roots to density of adjacent undisturbed soil.

C. Stripping:

1. Remove soil material containing sod, grass, or other vegetation to minimum depth of 6 inches from both borrow areas and areas to receive fill.
2. Deposit stripped material at locations as directed by OWNER.

END OF SECTION

SECTION 02300

EARTHWORK

PART 1 GENERAL

1.1 SUMMARY

A. Section includes:

1. Loosening, excavating, filling, grading, borrow, hauling, preparing subgrade, compacting in final location, wetting and drying, and operations pertaining to site grading for Embankment construction.
2. Backfilling and compacting to support Embankment construction.

1.2 RELATED SECTIONS

A. Section 02200 – Site Preparation

B. Section 02400 – Subgrade Preparation

C. Section 02714 – Geotextile Fabric

D. Section 02715 – Geonet Drainage Layer

E. Section 02771 – XR-5 Liner

1.3 REFERENCES

A. Latest Version of American Society for Testing and Materials (ASTM) Standards:

1. D 1556 - Standard Test Method for Density and Unit Weight of Soil in Place by the Sand Cone Method.
2. D 698 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3 (600 kN m/m^3)).
3. D6938 Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
4. D 4253 – Standard Test Method for Maximum Index Density and Unit Weight of soils Using a Vibratory Table

1.4 DEFINITIONS

A. Backfill adjacent to structure: Backfill within volume bounded by the exterior surfaces of structure, the surface of undisturbed soil in the excavation around structure, and finish grade around structure.

B. Embankments: Dikes, levees, berms, and similar facilities.

C. Excavation: Consists of loosening, removing, loading, transporting, depositing, and compacting in final location, wet and dry materials, necessary to be removed for purposes of construction of structures, ditches, grading, berms, roads, and such other purposes as are indicated on the Drawings.

D. Free draining Sump Fill: ½" minus free draining gravel containing no more than 5% minus P_{200} (fines) used in conjunction with drain net to facilitate monitoring and any removal that may be required from leak detection system.

1.5 SYSTEM DESCRIPTION

A. Performance requirements:
   1. Obtain acceptable import material from other sources if surplus soil obtained within Project site do not conform to specified requirements or are not sufficient in quantity.
   2. No extra compensation will be made for hauling of fill materials or for water required for compaction.
   3. Import of free draining sump fill will be required.

1.6 SUBMITTALS

A. Copy of Property OWNER's Agreement allowing placement of surplus soil material on their property.

B. Excavation plan.

C. Testing lab: Submit CONTRACTOR's proposed testing laboratory capabilities and equipment.

D. Test reports:
   1. Submit certified test reports of all tests specified to be performed by the CONTRACTOR.
   2. Sign and seal test reports by a registered PROFESSIONAL ENGINEER who practices geotechnical ENGINEERing and is registered in the State of Utah.

1.7 QUALITY ASSURANCE

A. Initial compaction demonstration:
   1. Adequacy of compaction equipment and procedures: Demonstrate adequacy of compaction equipment and procedures before exceeding any of following amounts of earthwork quantities:
      a. 100 linear feet of trench backfill.
      b. 50 cubic yards of backfill adjacent to structures.
      c. 100 cubic yards of embankment work.
      d. 100 cubic yards of fill.
      e. 50 cubic yards of roadway base material.
      f. 100 cubic yards of road fill.

2. Compaction sequence requirements: Until specified degree of compaction on previously specified amounts of earthwork is achieved, do not perform additional earthwork of the same kind.
3. After satisfactory conclusion of initial compaction demonstration and at any time during construction, provide confirmation tests as specified under the QA/QC Plan.

1.8 SEQUENCING AND SCHEDULING

A. Schedule earthwork operations to meet requirements specified in this Section for excavation and uses of excavated material.

B. If necessary, stockpile excavated material in order to use it at specified locations.

C. Excavation, backfilling, and filling: Perform excavation, backfilling, and filling during construction in manner and sequence that provides drainage away from critical work areas at all times.

PART 2 – PRODUCTS

1.1 MATERIALS

A. Water for compaction: Use water from source acceptable to ENGINEER as directed by OWNER.

B. Soil and rock materials:
   1. General:
      a. Provide native material and select material where specified or indicated on the Drawings.
      b. If suitable surplus cut materials are unavailable, obtain native material from approved borrow areas.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Verification of conditions:
   1. Character and quantity of material:
      a. Verify character and quantity of rock, gravel, sand, silt, water, and other inorganic or organic materials to be encountered in work to be performed.
      b. Determine gradation and shrinkage, and swelling of soil, and suitability of material for use intended in work to be performed.
      c. Determine quantity of material, and cost thereof, required for construction of backfills, cuts, embankments, excavations, fills, and roadway fills, whether from onsite excavations, or borrow areas. Include in cost of work to be performed.
      d. Include wasting of excess material, if required, in cost of work to be performed.

3.2 PREPARATION

A. Embankment construction:

1. For embankment areas, after clearing and topsoil removal is completed, scarify entire areas which underlie embankments to a depth of 6 inches and until surface is free of ruts, hummocks, and other features which would prevent uniform compaction by equipment to be used.
2. Recompact scarified areas to density specified for embankments before placing of embankment material.
3. If embankment areas have cemented rock, cobbles, or boulders, do not scarify the top 6 inches prior to compaction. Moisten the native soil and compact the coarse fill as specified in this Section.

B. Sloped surfaces for fill or foundations:

1. Foundations for fill having slopes in excess of 1 vertical to 4 horizontal:
   a. Bench or terrace to adequately key existing ground and fill built thereon.
2. Slopes of original hillsides: Bench minimum of 10 feet horizontally as fill is placed.
3. Provision of new benches:
   a. Start new bench wherever vertical cut of next lower bench intersects existing grade.
   b. Recompact material thus cut out along with new embankment material at no additional cost to the OWNER.

3.3 INSTALLATION

A. General:

1. Dispose of excavated materials, which are not required or are unsuitable for fill and backfill in lawful manner.
2. Dispose of surplus material on private property only when written permission agreement is furnished by OWNER of property. Submit copies of such agreements.
3. Obtain material required in excess of suitable material produced by cuts and excavation, from borrow areas subject to the material requirements specified.
4. Rocks, broken concrete, or other solid materials larger than 4 inches in greatest dimension: Remove from project site at no additional cost to OWNER.
5. Stabilization of subgrade: Provide materials used, or perform work required, to stabilize subgrade so it can withstand loads which may be placed upon it by CONTRACTOR's equipment.

B. Borrow area: If there is insufficient borrow area on Project site, import material from off-site.

1. Where material is required, import material from source located off Project site selected by the CONTRACTOR and subject to acceptance by the ENGINEER.

2. There will be no additional cost to the Contract for use of imported material with the exception of leak detection sump fill.

C. Compaction:
1. Provide specified compaction for backfills, cuts, embankments, fills, roadway fills, and other earthwork.
2. Perform confirmation tests to verify and confirm that work has complied, and is complying at all times, with compaction requirements specified in this Section for initial compaction demonstration and field quality control testing.
3. In-place density of compacted backfills, cuts, embankments, fills, and ramp/roadway fills determined in accordance with ASTM D 1556 or with ASTM D 6938.
4. Maximum density obtained in laboratory when tested in accordance with ASTM D 698.
5. To prevent damage to structures due to backfilling operations, as required, place backfill with equipment that does not exceed H-20 loading, within a distance from the face of the structure of not less than 1/2 the depth of backfill. The depth of backfill is the distance between the level being compacted and the bottom of the excavation. Outside this distance, heavier compaction equipment may be used.
6. Compact to percentage of maximum density as follows:
   a. Utility trenches: 95 percent.
   Embankments: 95 percent.
   c. Leak Detection Sump Gravel: 80 percent relative density
   d. Spoil areas 90 percent.
   e. Under roadways, parking and storage areas, curbs, and sidewalks: 95 percent.
   f. Upper 6 inches of cuts: 95 percent.
   g. Fills: 95 percent.

D. Materials for backfills, embankments, fills, roadway fills:
1. General:
   a. Obtain import material from other sources if surplus materials from within Project site or borrow areas do not conform to specified requirements or are not sufficient in quantity for construction of Project.
2. Embankments:
   a. Native material, Select material, or imported material meeting the requirements of native material, select material, unless otherwise specified or indicated on the Drawings.
3. Fills:
   a. Native material, or imported material meeting the requirements of select material unless otherwise specified or indicated on the Drawings.

E. Placement:
1. General:
   a. Lines and grades:
      1) Construct backfills, embankments, fills, and road fills, at locations and to lines and grades indicated on the Drawings.
      2) Overbuild all permanent fill slopes by at least 1 foot and then cut to final grade to provide adequate compaction of the remaining

fill.

2. Embankments:
   a. Place loose material in successive layers that do not exceed 8 inches in depth after compaction.
   b. Bring each layer to a moisture content within ± 2 percent of optimum moisture content before compacting.
   c. All lifts of fill materials shall be compacted to 95% of the maximum dry unit weight determined using the ASTM D698 standard method of compaction.
   d. Defective compacted embankments: Remove/rework and recompact.
   e. Clods or hard lumps of earth of 4 inches in greatest dimension: Break up before compacting material in embankments, except as provided as follows:
      1) When fill material includes large rocky material or hard lumps, such as hardpan or cemented gravel which cannot be broken readily, distribute such material throughout fill.
      2) Place sufficient earth or other fine material around larger material as it is deposited so as to fill interstices and produce dense, compact fill. Do not place such material within 2 feet of finish grade of fill.

3.4 FIELD QUALITY CONTROL

A. Tests:
   1. Confirmation tests:
      a. CONTRACTOR's responsibilities:
         1) Accomplish specified compaction for backfills, fills, and other earthwork.
         2) Control operations by confirmation tests to verify that compaction work complies, and is complying at all times, with requirements specified in this Section concerning compaction, control, and testing.
         3) Cost of confirmation tests: Paid for by the CONTRACTOR.
         4) Qualifications of CONTRACTOR's testing laboratory: Perform confirmation testing by soils testing laboratory acceptable to the ENGINEER.
         5) Copies of confirmation test reports: Submit promptly to the ENGINEER.
      b. Frequency of confirmation testing:
         1) Perform testing not less than the following:
            a) Embankments: 1 test every 500 cy or every other lift, whichever is more frequent.
            b) Pipe Trenches:
               (1) 2 every 500 linear feet
               (2) At each test location include tests for each type or class of backfill from bedding to finish grade.
   2. Compliance tests:
      a. Periodic compliance tests will be made by the ENGINEER to verify that compaction is meeting requirements previously specified.
      b. If compaction fails to meet specified requirements, perform remedial work by one of the following methods:
         1) Remove and replace materials at proper density.
         2) Bring density up to specified level by other means acceptable to

theENGINEER.

c. Retesting:
   1) CONTRACTOR bears the costs of retesting required to confirm and verify that remedial work has brought compaction within specified requirements.
   2) CONTRACTOR's confirmation tests during performance of remedial work: Double the normal rate specified.

B. Tolerances:
   1. Finish grading of embankments, and fills:
      a. Perform fine grading such that finish surfaces are never above the grade or cross section indicated on the Drawings and are never more than 0.10 feet below.
   2. Finish grading of surfaces:
      a. Reasonably smooth, compacted, and free from irregular surface changes.
      b. Provide degree of finish that is ordinarily obtainable from blade grader operations, except as otherwise specified.
      c. Finish ditches and gutters so that they drain readily.

3.5 ADJUSTING

A. Finish grades of excavations, backfills, and fills:
   1. Repair and reestablish grades to required elevations and slopes due to any settlement or erosion that may occur from action of the elements or any other cause prior to final acceptance.

3.6 PROTECTION

A. Finish grades of backfills, cuts, excavations, and fills:

B. Protect newly graded areas from erosion and deterioration.

END OF SECTION

SECTION 02400

SUBGRADE PREPARATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Final subgrade preparation.

B. Certification of subgrade soil.

1.2 RELATED SECTIONS

A. Section 02200 – Site Preparation

B. Section 02300 – Earthwork

C. Section 02714 – Geotextile Fabric

D. Section 02715 – Geonet Drainage Layer

E. Section 02771 – XR-5 Liner

1.3 PROJECT RECORD DOCUMENTS

A. Submit subgrade certification reports to QA Inspector to countersign prior to covering the area with geotextile cushion and initial (lower) geosynthetic liner. Geotextile and liner installation work cannot proceed without written certification reports and approval from QA Inspector.

PART 2 – PRODUCTS

2.1 MATERIALS

A. Only limited offsite soil material will be required for this portion of the project. Significant portions of the subgrade preparation may require excavation. Suitable excavated materials will be used as compacted fill with ENGINEERS prior approval.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify existing site conditions are in a condition suitable for initiating final grading procedures.

3.2 FINAL GRADING

A. Prepare subgrade soils to receive geotextile cushion and initial liner by means of grading, rolling and/or track walking.

B. Subgrade will be free from rocks or other sharp objects, mounds, depressions, ridges or any anomaly that may cause concentrated stress or puncture to the liner.

3.3 SUBGRADE APPROVAL AND CERTIFICATION

A. CONTRACTOR will certify subgrade prior to material placement.

B. CONTRACTOR (QC Inspector) will provide QA Inspector with daily, written certification of subgrade approval for the QA Inspector's countersignature prior to liner placement.

END OF SECTION

SECTION 02714

GEOTEXTILE FABRIC

PART 1 – GENERAL

1.1 SECTION INCLUDES

A. Geotextile fabric

1.2 RELATED SECTIONS

A. Section 02200 – Site Preparation

B. Section 02300 – Earthwork

C. Section 02400 – Subgrade Preparation

D. Section 02715 – Geonet Drainage Layer

E. Section 02771 – XR-5 Liner

1.3 REFERENCES

A. Latest Version of American Society for Testing and Materials (ASTM) Standards:

B. Latest Version of the Geosynthetic Research Institute (GRI) Standards:

1.4 DEFINITIONS

A. Minimum Average Roll Value (MARV): Property value calculated as typical minus two standard deviations. Statistically, it yields a 97.5 percent degree of confidence that any sample taken during quality assurance testing will exceed value reported.

B. Typical Roll Value: Property value calculated from average or mean obtained from test data.

1.5 SUBMITTALS

The CONTRACTOR shall provide the ENGINEER a certificate stating the name of the geotextile manufacturer, product name, style, chemical compositions of filaments or yarns and other pertinent information to fully describe the geotextile. ENGINEER will forward material approval to both the QA and QC personnel.

A. ENGINEER will provide written approval of geotextile prior to ordering material.

B. The Manufacturer is responsible for establishing and maintaining a quality control program to assure compliance with the requirements of the specification.

C. Manufacturing Quality Control (MQC) test results shall be provided upon request.

1.6 DELIVERIES, STORAGE, AND HANDLING

A. Geotextile labeling, shipment and storage shall follow ASTM D 4873. All geotextile shall be stored, handled and installed in accordance with manufacturer's referenced UV exposure time.

B. Product labels shall clearly show the manufacturer or supplier name, style name, and roll number.

C. Each shipping document shall include a notation certifying that the material is in accordance with the manufacturer's certificate.

D. Each geotextile roll shall be wrapped with a material that will protect the geotextile from damage due to shipment, water, sunlight, and contaminants. The protective wrapping shall be maintained during periods of shipment and storage. If the wrapping is damaged prior to installation, the outer wrap of geotextile material must be discarded before installation.

1.7 QUALITY ASSURANCE SAMPLING, TESTING, AND ACCEPTANCE

Geotextile: No testing required.

PART 2 – PRODUCTS

2.1 MANUFACTURERS

A. Propex

B. Approved Equivalent

2.2 MATERIALS

A. Geotextile (Propex 861 or approved equal)
   1. High strength polypropylene non-woven geotextile with minimum mass per unit area of 8 oz/yd^2
   2. Resistant to ultraviolet degradation and to biological and chemical environments normally found in soils.
   3. Minimum Average Roll Values (MARV) as indicated in the following table:

Property	Test Method	Units	Property Requirement
Grab Tensile Strength	ASTM D 4632	lbs	170
Puncture Strength	ASTM D 4833	lbs	575
Trapezoidal Tear	ASTM D 4533	lbs	95
Apparent Opening Size (AOS)	ASTM D 4751	US Sieve	80
Permittivity	ASTM D 4491	sec^{-1}	1.5

PART 3 – EXECUTION

3.1 PREPARATION

A. Subgrade should have been smoothed and debris removed prior to geotextile placement. A. Prepare surfaces to receive geotextile; remove any foreign matter from the subgrade.

3.2 INSTALLATION

A. The geotextile shall be placed in intimate contact with subgrade without wrinkles or folds.The geotextile shall be placed in such a manner that placement of the overlying materials will not excessively stretch so as to tear the geotextile.

B. Sandbags shall be used to hold fabric in place as necessary. Penetrating anchors may be allowed if approved by the ENGINEER.

C. Adjacent rolls of geotextile shall be overlapped a minimum of 6 inches.

D. Overlapped roll ends shall be a minimum of 2 feet in all instances or as directed by the ENGINEER.

E. When overlapping, successive lengths of the geotextile shall be placed beneath the previous filled panel or roll.

F. Care shall be taken during installation so as to avoid damage occurring to the geotextile as a result of the installation process. Should the geotextile be damaged during installation the material shall be removed and replaced by the CONTRACTOR.

G. Field monitoring shall be performed to verify that fill placement does not damage the geotextile.

H. Any geotextile damaged during subsequent liner placement shall be replaced as directed by the QA Inspector, at the CONTRACTOR's expense.

END OF SECTION

SECTION 02715

GEONET DRAINAGE LAYER

PART 1 – GENERAL

1.1 SECTION INCLUDES

This section covers the work necessary to furnish all labor, equipment and materials necessary to the Geonet Drainage Layer, as specified herein, as shown on the Drawings, and in accordance with the Construction QA/QC Plan.

1.2 RELATED SECTIONS

A. Section 02200 – Site Preparation

B. Section 02300 – Earthwork

C. Section 02400 – Subgrade Preparation

D. Section 02714 – Geotextile Fabric

E. Section 02771 – XR-5 Liner

1.3 REFERENCES

A. Latest Version of American Society for Testing and Materials (ASTM Standards:

B. Latest Version of the Geosynthetic Research Institute (GRI) Standards:

1.4 SUBMITTALS

Prior to transporting any Geonet to the site, the CONTRACTOR shall submit the following documentation on the Geonet to the ENGINEER for written approval. ENGINEER shall forward material approval to both the QA and QC personnel.

A. The CONTRACTOR shall submit to the ENGINEER the following information on the Geonet:
   1. Copies of quality control certificates issued by the Geonet manufacturer. The certificate should include:
      a. Roll numbers lot or batch numbers and identification;
      b. Results of quality control tests, including descriptions of test methods used.

B. The CONTRACTOR shall also provide
   1. One 8" X 10" sample of the Geonet to be used on the project.
   2. Seaming, overlap, and repair requirements as defined by the manufacturer. The ENGINEER shall forward seaming requirements to both the QA and QC personnel.

1.5 QUALIFICATIONS

The CONTRACTOR shall accept and retain full responsibility for all materials and installation and shall be held responsible for any defects in the completed system. The CONTRACTOR shall obtain the services of a Geonet Manufacturer and experienced Installer, who shall meet the following qualifications.

A. Manufacturer
   1. The Geonet Manufacturer shall be responsible for the production and delivery of Geonet and shall be a well-established firm with more than five years experience in the manufacture of Geonet. The Manufacturer shall submit a Quality Control Plan to the ENGINEER listing:
      a. Certified minimum property values of the proposed Geonet with the tests used to determine those properties including the frequencies at which the tests shall be performed.

B. Installer
   1. The Installer shall be responsible for field handling, storing, deploying, seaming or joining, temporary restraining (against wind), anchoring systems, and other site aspects of the Geonet drainage layer.
   2. The Installer shall be trained and qualified to install Geonet. The Installer's qualifications shall be submitted to the ENGINEER for review. ENGINEER to forward installers approval to both the QA and QC personnel.

1.6 WARRANTY

A. The Manufacturer shall furnish the OWNER with a warranty against defects in workmanship and material.

PART 2 – PRODUCTS

2.1 GEONET PROPERTIES

A. The Manufacturer shall supply Geonet having properties that are in accordance with the required properties shown in this section. Acceptable product is the GSE Environmental PermaNet or equivilent.

B. Acceptable Manufacturers
   1. GSE Environmental
   2. Approved (by ENGINEER) Alternative.

2.2 LABELING

A. The Geonet shall be supplied in rolls wrapped in protective covers and labeled with the following information:
   1. Manufacturer's name;
   2. Product identification;
   3. Roll number; and
   4. Roll dimensions.

2.3 TRANSPORTATION

A. Transportation of the Geonet shall be the responsibility of the CONTRACTOR. The CONTRACTOR shall be liable for all damages to the materials incurred prior to and during transportation to the site.

PART 3 – EXECUTION

3.1 FAMILIARIZATION

Prior to implementing any of the work described in this Section, the CONTRACTOR shall become thoroughly familiar with all portions of the work falling within this Section.

3.2 INSPECTION

A. Prior to implementing any of the work in the Section, the CONTRACTOR shall carefully inspect the installed work of all other Sections and verify that all work is complete to the point where the installation of the Section may properly commence without adverse impact.

B If the CONTRACTOR has any concerns regarding the installed work of other Sections, he shall notify the QA Inspector in writing within 48 hours of his site inspection. Failure to inform the QA Inspector in writing or installation of the Geonet will be construed as the CONTRACTOR's acceptance of the related work of all other Sections.

3.3 HANDLING AND PLACEMENT

A. After the Geonet has been installed, seamed, and approved by the QC Inspector and QA Inspector, the surface shall be cleaned and free of excess dirt and debris. Placement of the Geonet shall be documented on the Geonet Panel Placement Log and on the Daily Field Log.

B. The CONTRACTOR shall handle all Geonet in such a manner as to ensure it is not damaged in any way. The CONTRACTOR shall take any necessary precautions to prevent damage to underlying layers during placement of the Geonet.

C. The Geonet should be installed in the direction of the slope or as specified by the Manufacturer.

D. All Geonet shall be weighted with sandbags or the equivalent. Such sandbags shall be installed during placement and shall remain until replaced with cover material.

E. The Geonet shall be properly anchored to resist sliding according to the Drawings. Anchor trench compacting equipment shall not come into direct contact with the Geonet.

F. If necessary, the Geonet shall be positioned by hand after being unrolled to minimize wrinkles.

G. In applying fill material, no equipment can drive directly on the Geonet. The specified fill material shall be placed and spread utilizing vehicles with a low ground pressure. The cover soil shall be placed on the Geonet in a manner that prevents damage to the Geonet. Placement of the upper liner material shall proceed immediately following placement and inspection of the Geonet.

3.4 SEAMS AND OVERLAPS

Geonet will be secured or seamed to the like component at overlaps.

A. Geonet Components
   1. Adjacent edges of Geonet along the length of the geonet, should be overlapped or anchored as approved by the Manufacturer based on the site-specific conditions.
   2. Adjoining Geonet rolls (end to end) along the roll width should be shingled down in the direction of the slope, with a minimum of 36-inch overlap. Geonet should be tied every 12 inches across the roll width and every 6 inches in the anchor trench or as recommended by the Manufacturer.
   3. CONTRACTOR shall place the Geonet rolls such that no movement of the Geonet occurs while placing the upper liner. CONTRACTOR to consult with Manufacturer to determine if the Geonet product is capable of being overlapped or if a continuous piece of Geonet need to extend from anchor trench to anchor trench.

3.5 REPAIR

A. Prior to covering the deployed Geonet, each panel shall be inspected for damage resulting from construction. Any damage and/or associated repairs shall be noted on the Daily Field Log.

B. Any rips, tears or damaged areas on the deployed Geonet shall be repaired by placing a patch extending 12 inches beyond the edges of the damaged area. The patch shall be secured to the original Geonet as recommended by the Manufacturer.

END OF SECTION

SECTION 02717

XR-5 Liner

PART 1 – GENERAL

1.1 SECTION INCLUDES

A. Furnish and install a 30 mil XR-5 bottom and 38 mil XR-5 upper liner as shown in the drawings.

1.2 RELATED SECTIONS

A. Section 02200 – Subgrade Preparation

B. Section 02300 – Earthwork

C. Section 02400 – Subgrade Preparation

D. Section 02714 – Geotextile Fabric

E. Section 2715 – Geonet Drainage Layer

1.3 REFERENCES

A. Latest Version of American Society for Testing and Materials (ASTM) Standards:

B. Latest Version of the Geosynthetic Research Institute (GRI) Standards:

1.4 DEFINITIONS

A. Batch: A quantity of resin, usually the capacity of one railcar, used in the fabrication of the geomembrane sheet. The finished sheet will be identified by a roll number corresponding to the particular quantity of resin used.

B. Bridging: The condition when geomembrane becomes suspended over its subgrade due to contraction of the material or poor installation.

C. Construction Quality Control (QC) Personnel: The party, secured by the CONTRACTOR, that is responsible for all of the CONTRACTOR's Construction Quality Control activities related to installation of the geosynthetic components of the lining system.

D. Construction Quality Assurance (QA) Personnel: The site representative of the OWNER responsible for site Quality Assurance documentation.

E. Extrudate: The molten polymer that is emitted from an extruder during seaming using either extrusion fillet or extrusion flat methods. The polymer is initially in the form of a ribbon rod, bead or pellets.

F. Fabricator: The party responsible for the fabrication of geomembrane panels constructed from rolls received from the manufacturer.

G. Geomembrane: An essentially impermeable membrane used as a solid or liquid barrier. In the context of this project it implies a XR-5 liner product.

H. Geomembrane Manufacturer: The party responsible for the production of the geomembrane rolls from resin and for the quality of the resin.

I. Geomembrane: An essentially impermeable membrane used as a solid or liquid barrier. Synonymous term for geomembrane.

J. Subgrade: The soil or upon which the geomembrane lies.

K. Installer: The party responsible for field handling, transporting, storing, deploying, seaming, temporary restraining (against wind), and installation of the geomembrane.

L. Panel: The unit area of geomembrane that will be seamed in the field. If the geomembrane is not fabricated into panels in a factory, a panel is identified as a roll or portion of a roll without any seams.

1.5 SUBMITTALS

A. Product Data: Submit the following to ENGINEER for written approval (ENGINEER shall forward approval to both QA and QC personnel) prior to ordering:

1. Resin Data.

   a. Statement of production date or dates.
   b. Product Certifications.
   c. Copy of quality control certificates issued by manufacturer.
   d. Test reports from manufacturer.

2. Geomembrane Roll Data.

   a. Statement of production date or dates.
   b. Laboratory test results and certification stating that the geomembrane meets the product requirements (see Part 2 Products).
   c. Certification stating that all geomembrane rolls are furnished by one supplier, and that all rolls are manufactured from one resin type obtained from one resin supplier.
   d. Copy of quality control certificates issued by manufacturer.
   e. Test reports from the manufacturer.
   f. Typical results of complete notched constant tensile load test (GRI-GM-5) for specified resin and sheet thickness.

g. Statement certifying that no reclaimed polymer is added to the resin.
h. Statement listing percentages/total of processing aids, antioxidants, and other additives other than carbon black added to or in the resin.
i. Geomembrane delivery, storage, and handling instructions.
j. Geomembrane installation instructions.
k. Sample warranties for review.

3. Extrudate Beads and/or Rod.

a. Statement of production date or dates.
b. Laboratory certification stating that the extrudate meets the product requirements (see Part 2 - Products).
c. Certification stating that all extrudate is manufactured by one manufacturer and resin is supplied from one supplier.
d. Copy of quality control certificates issued by manufacturer. e. Test reports from the manufacturer.
f. Certification stating that the extrudate bead or rod resin is the same type, from the same manufacturer and compatible with the resin used to manufacture the geomembrane supplied for this project.

B. Schedules and Drawings (Installer)

1. Submit installation schedule to OWNER and ENGINEER. Include hours worked per day, week and per shift.

2. Installation layout drawings: Four weeks prior to installation of geomembrane, submit drawings to ENGINEER showing the panel layout indicating both fabricated (if applicable) and field seams, and details not conforming to the Drawings. Upon ENGINEER review, use these drawings for installation of geomembrane.

C. Qualifications (Installer).

1. Submit two weeks prior to installation, name of installer, and resume of installation supervisor/field ENGINEER to be assigned to the project. ENGINEER shall review and approve installers and forward approval to both the QA and QC personnel.

2. Submit, two weeks prior to installation, resume of master seamer.

3. Submit, two weeks prior to installation, resumes of installation seamers performing seaming operations.

D. Field Quality Control Documents (Installer). Follow project Construction QA/QC Plan. E.

Submit upon completion of the installation: (Installer).

1. Certificate stating the liner has been installed in accordance with the Drawings and Specifications.

2. The warranty obtained from the manufacturer/fabricator and the installation warranty.
3. As-built drawings showing location of panels, seams, repairs, patches, and destructive samples, including measurements.

4. Copies of seam test results.

1.6 QUALIFICATIONS

A. Manufacturer/Fabricator/Installation Qualifications: The following are pre-qualified. Substitutions may be considered.

1. Seaman Corporation
2. Colorado Lining International

B. Installer: Must have successfully installed a minimum of 5,000,000 square feet of hot air welded geomembrane with documented references.

C. Master Welder Qualifications: Must have completed a minimum of 2,000,000 square feet of geomembrane seaming work using the type of seaming apparatus proposed for use on this project.

D. Other Seamers Qualifications: Must have seamed a minimum of 1,000,000 square feet of XR-5 geomembrane.

1.7 LABELING, DELIVERY, STORAGE, AND HANDLING (MANUFACTURER)

A. Labeling.

1. Each roll of geomembrane delivered to the site shall be labeled by the manufacturer. The label shall clearly state the manufacturer's name, product identification, thickness, length, width and roll number.

2. The label shall be found on either of the end caps, an inside edge of the core, and outside the core.

B. Delivery.

1. Deliver materials to the site only after ENGINEER accepts required submittals.

2. Separate damaged rolls from undamaged rolls and store at locations designated by QA Inspector until QA Officer determines proper disposition of the material.

3. QA Officer will determine damage.

4. Deliver in rolls, do not fold.

C. Storage on Site: (Installer).

1. Store geomembrane rolls in the space allocated by OWNER.

2. Store geomembrane rolls to protect from puncture, dirt, grease, water, moisture, mud, mechanical abrasions, excessive heat or other damage.

3. Store geomembrane rolls on CONTRACTOR prepared surface (not on wooden pallets).

4. Stack geomembrane no more than four rolls high.

D. Handling on Site: (Installer).

1. Use appropriate handling equipment to load, move, or deploy geomembrane rolls. Appropriate handling equipment includes cloth chokers and spreader bar for loading, spreader, and roll bars for deployment. Dragging panels on ground surface will not be permitted.

2. Do not fold geomembrane material; folded material will be rejected.

3. CONTRACTOR is responsible for off-loading, storage, and transporting material from storage area to installation site.

1.8 QUALITY CONTROL

A. The CONTRACTOR will engage and pay for the services of a party responsible for the continuous testing and documentation of the geomembrane material being installed. Testing will be performed in accordance with both the Construction QA/QC Plan and these Specifications.

1.9 QUALITY ASSURANCE

A. OWNER will engage and pay for the services of independent Construction Quality Assurance (QA) Personnel.

2.0 WARRANTY

A. Provide manufacturer's warranty for geomembrane material in compliance with provisions of the Conditions of the Contract. Provide a minimum 20-year pro rata warranty for the material against deterioration due to exposure to the elements, either exposed or buried. The warranty for material must cover costs of material replacement and installation; assuming the area is rendered in a clean, dry unencumbered condition. In the event the area cannot be rendered as such, compensation for defective material will be provided to OWNER on a pro rata basis for the estimated cost to OWNER at that time of supplying and installing material to a clean, dry, and unencumbered condition by a third party installer.

B. Installation: Provide an installation warranty for geomembrane material in compliance with the conditions of the Contract. Provide a minimum of 2-year non-pro rata warranty for the installation against defects.

PART 2 – PRODUCTS

2.1 GEOMEMBRANE

All geomembrane material shall be an XR-5 material manufactured by Seaman Corporation. The lowermost liner shall be composed of 8130 XR-5 (30 mil) with the upper liner being 8138 XR-5 (38 mil).

2.2 HOT AIR WELDING

A. All field seams shall be joined via hot air welded (dielectric) until a visible bead of polymer is extruded at the seam in accordance with manufacturers recommendations. A minimum 2" overlap is required at all seams.

2.3 WELDING EQUIPMENT

A. Supplied seam welding accessories must meet the following requirements:

1. Maintain sufficient operational seaming apparatus to continue work without delay.
2. Use power source capable of providing constant voltage under combined line load.
3. Provide protective lining and splash pad large enough to catch spilled fuel under electric generator, if located on liner.
4. Tensiometers capable of measuring seam strength, calibrated and accurate as per applicable ASTM standards.
5. Dies for cutting seam samples.

2.5 MANUFACTURER SOURCE QUALITY CONTROL

A. Provide Manufacturers Quality Control Documentation.

PART 3 – EXECUTION

3.1 EXAMINATION OF GEOMEMBRANE SUBSURFACE

A. Follow procedures set forth in the QA/QC Plan. No geomembrane shall be deployed without written subgrade acceptance.

B. Grade changes rounded to min. 12-inch radius.

C. Subgrade will be free from rocks or other sharp objects, mounds, depressions, ridges or any anomaly that may cause concentrated stress or puncture the geomembrane.

3.2 PREPARATION

A. Repair damage caused to subgrade during deployment.

B. Prepare anchor trenches as shown in Drawings.

C. Perform trial seam welds as follows:

1. Perform trial welds on samples of geomembrane to verify the performance of welding equipment, seaming methods, and conditions.

2. No seaming equipment or welder will be allowed to perform production welds until equipment and welders have successfully completed trial weld.

3. Frequency of trial welds:

   a. Minimum of one trial weld per day prior to the start of work in the morning and one after lunch.
   b. When directed by the QA Personnel.

4. Make trial welds in the same surroundings and environmental conditions as the production welds, i.e., in contact with subgrade.

5. Make trial weld sample at least 2 feet long and 12 inches wide with the seam centered lengthwise.

6. Cut six, one-inch wide test strips from opposite ends of the trial weld.

7. Allow coupons (strips) to cool before testing. Testing should be conducted at 70 degrees (plus or minus 4 degrees) Fahrenheit. Coupons temperatures greater than 70 degrees may result in lowered strengths.

8. Quantitatively test specimens for peel adhesion and bonded seam strength. Peel and shear values shall meet or exceed the following as specified in GRI GM-19:

Geomembrane Thickness	30 mils	38 mils
Hot Wedge Seams [1]		
Adhesion Ply [2], lb/in	15	
Adhesion Heat Welded Seam, lb/2in	40	
Dead Load Seam Strength [3], lb/in	220	
Bonded Seam Strength, lb	550	

Notes for Table

1. Also for hot air and ultrasonic seaming methods
2. Value listed for minimum or film tearing bond
3. 4 hour test at 70 degrees Fahrenheit

9. Repeat the trial weld in its entirety when any of the trial weld samples fail in either peel or shear.

10. When repeated trial weld fails, do not use welding apparatus and welder until deficiencies or conditions are corrected and two consecutive successful trial welds are achieved.

3.3 INSTALLATION

A.Protection

1. Do not use geomembrane surface as work area for preparing patches, storing tools and supplies, or other uses. Use protective cover as work surface, if necessary.

2. Instruct workers about requirements for protection of geomembrane such as handling geomembrane material in high winds, handling equipment, and walking on geomembrane surfaces. Shoes of personnel walking on geomembrane shall be such that they will not damage the liner. Smoking, eating, placing heated equipment directly on geomembrane or other activities that may damage geomembrane is prohibited.

3. Hold a daily meeting to discuss and coordinate work activities as detailed in the QA/QC Plan.

4. Do not operate equipment without spark arresters in vicinity of geomembrane material, or place generators or containers of flammable liquid on geomembrane without the use of a splash pad.

5. Protect geomembrane from vehicular traffic and other hazards.

6. Keep geomembrane clean and free of debris during placement.

B. Geomembrane Deployment.

Give careful consideration to the timing and temperature during deployment. The QC Personnel will focus on verifying that (a) there is no bridging or stresses in the geomembrane and (b) there are no wrinkles in the geomembrane that will fold over when covering with soil material. Ideally, deployment, welding, and covering would all occur at the same temperature. In a practical sense, CONTRACTOR should strive to perform these activities within as narrow a temperature range as practical, and avoid these activities during peak hot or cold conditions. Do not deploy geomembrane during precipitation or moisture events (e.g. fog, drizzle, dew), or during excessive wind.

2. Panel Identification: Assign each panel an identifying code number of letter consistent with CONTRACTOR's submitted panel layout drawing. The coding should be coordinated with the QA Personnel.

3. Daily Panel Deployment: Deploy no more panels in one shift than can be welded during that same day.

4. Do not deploy in the presence of excessive moisture, precipitation, ponded water, or high winds.

5. Do not damage geomembrane by handling, trafficking, leakage of hydrocarbons or any other means.

6. Install miscellaneous products required to complete geomembrane installation according to manufacturer's recommendations.

7. Unroll geomembrane panels using methods that will not damage, stretch or crimp geomembrane. Protect underlying surface from damage. CONTRACTOR shall be solely responsible for protection of the subgrade. The QC Personnel will verify that the soils underlying the geomembrane are not damaged.

8. Use methods that minimize wrinkles and differential wrinkles between adjacent panels.

9. Temporarily weight geomembrane sheets with sandbags as necessary to anchor or hold them in position during installation. Use continuous hold-downs along edges to reduce wind flow under sheet.

   a. Sandbag fabric shall be sufficiently close knit to preclude fines from working through bags.
   b. Substitution of sandbags with tires or the use of paper bags even plastic lined paper bags is prohibited. Burlap bags may be used if lined with plastic.
   c. Immediately remove damaged or improperly sealed bags from the work area, and clean up the area affected.

10. Anchor edges of geomembrane as shown in Drawings.

11. Protect geomembrane in area of heavy traffic by placing protective cover that is compatible with and will not damage geomembrane.

12. Repair damage to subgrade or other underlying materials prior to completing deployment of geomembrane.

13. Do not allow vehicular traffic directly on geomembrane, with the exception of a low psi, lightweight vehicle such as a 4-wheel ATV or similar equipment.

14. Remove wrinkled or folded material.

15. Visually inspect geomembrane for imperfections. Mark faulty or suspect areas for repair.

16. Install material to account for shrinkage and contraction while avoiding wrinkles. Install material stress-free with no bridging before it is covered. Add material as needed to avoid bridging.

17. Before wrinkles fold over, attempt to push them out. For wrinkles that cannot be pushed out, cut them out and repair cuts at the direction of the QA Personnel.

C. Geomembrane Seam Layout.

1. Orient seams parallel to line of a maximum slope, i.e., orient down not across slope.

2. Minimize number of field seams in corners, odd-shaped geometric locations and outside corners.

3. Keep horizontal seams (seams running approximately parallel to slope contours) at least 6 feet away from toe or crest of slope.

4. Use seam numbering system compatible with panel number system.

5. Shingle panels on all slopes and grades as indicated in panel layout drawing.

D. Geomembrane Seam Welding Personnel.

1. Provide at least one welder (master welder) who has experience welding over 5 million square feet of geomembrane using the same type of welding apparatus in use at site.

2. Qualify personnel performing welding operations by experience and by successfully passing field-welding tests performed on site.

3. Master welder will provide direct supervision over other welders.

E. Geomembrane Seam Welding Equipment.

1. Extrusion welder: Equipped with gauges showing temperatures in extruder apparatus and at nozzle. Temperature at nozzle may be measured by external temperature gauges.

2. Fusion welder: Automated variable speed vehicular mounted apparatus equipped with devices adjusting and giving temperatures at wedge. Pressure controlled by spring, pneumatic, or other system that allows for variation in sheet thickness. Rigid frame fixed position equipment is not acceptable.

3. Maintain adequate quality of welding apparatus and spare welders in order to avoid delaying the project.

4. Use power source capable of providing constant voltage under combined line load.

5. Keep liner feed line clean and free of debris.

F. Geomembrane General Welding Procedures:

1. Do not commence welding with welding equipment until trial weld test sample, made by that equipment, passes test.

2. Clean surface of grease, moisture, dust, dirt, debris, or other foreign material.

3. Overlap panels a minimum 3 inches for extrusion welding.

4. Do not use solvents or adhesives.

5. Extend welding to the outside edge of all panels.

6. If required, provide a firm substrata by using a flat board, conveyor belt, or similar hard surface directly under the weld overlap to achieve firm support.

7. Provide adequate illumination if welding operations are carried out at night.

8. Cut fishmouths or wrinkles along the ridge of the wrinkle in order to achieve a flap overlap. Extrusion weld the cut fishmouths or wrinkles where the overlap is more than 3 inches. When there is less than 3 inches overlap, patch with an oval or round patch extending a minimum of 6 inches beyond the cut in all directions.

9. Weld only when ambient temperature, measured immediately above, but not in contact with the geomembrane, is between 40°F (5°C) and 104°F (40°C).

G. Geomembrane Defects and Repairs.

1. Examine all welds and non-weld areas of the geomembrane for defects, holes, blisters, undispersed raw materials, and any sign of contamination by foreign matter. The surface of the geomembrane shall be clean at the time of the examination.

2. Repair and non-destructively test each suspect location both in weld and non-weld areas. Do not cover geomembrane at locations which have been repaired until test results with passing values are available.

H. Geomembrane Extrusion Type of Welding.

1. Use extrusion welding only for repairs (e.g., patches, caps) and areas not accessible to fusion welding equipment.

2. Purge welding apparatus of heat-degraded extrudate before welding.

3. Bevel top edges of geomembrane a minimum of 45 degrees and full thickness of geomembrane before extrusion welding.

4. Clean seam welding surfaces of oxidation by disc grinder or equivalent not more than 30 minutes before extruding weld. Change grinding discs frequently. Do not use clogged discs.

5. Do not remove more than 4 mils of material when grinding.

6. Grind across, not parallel to, welds.

7. Cover entire width of grind area with extrudate. Abrasion from grinding shall not extend beyond the area extruded.

8. When restarting welding, grind ends of all welds that are more than five minutes old.

I. Geomembrane Hot Wedge Welding.

1. Place smooth insulating plate or fabric beneath hot welding apparatus after usage.

2. Protect against moisture build-up between panels.

3. If welding cross seams, conduct field test welds at least every four hours.

4. Bevel edges of top and bottom panels on cross seams.

5. Do not weld on geomembrane until equipment has passed trial weld test.

6. Extrusion-weld a repair patch over all seam intersections as described in 3.5.

3.4 FIELD QUALITY CONTROL AND QUALITY ASSURANCE

A. General

1. Manufacturer, Fabricator, and Installer will participate in and conform to all terms and requirements of the Construction QA/QC Plan, Drawings, and these Specifications. CONTRACTOR is responsible for assuring this participation. Quality control and quality assurance requirements are as specified in this paragraph and as presented in the Construction QA/QC Plan. If there is a discrepancy in the construction documents, the order of hierarchy shall be 1) Plans, 2) QA/QC manual, and 3) Specifications.

B. Conformance Testing (Performed by QC with separated equipment).

1. Perform conformance testing at the rate of 1 QC test per every 20 QA tests.

C. Field Testing (Performed by Installer).

1. General: Non-destructively test all field seams over their full length using a vacuum test unit, pressure testing, or other approved methods. Perform testing as the seaming progresses and not at the completion of all the field seaming. Complete all required repairs in accordance with this Specification and accepted Industry Standards.

2. Vacuum Testing.

   a. Equipment, comprised of the following:

      1) A vacuum box assembly consisting of a rigid housing, a transparent viewing window, a soft neoprene gasket attached to the bottom, port hole, or valve assembly, and a vacuum gauge.
      2) A vacuum pump assembly equipped with a pressure control.
      3) A rubber pressure/vacuum hose with fittings and connections.
      4) A soapy solution and an applicator.

   b. Test Procedures.

      1) Place the box over the area wetted with a soapy solution.
      2) Ensure that a leak-tight seal is created.
      3) Energize the vacuum pump and reduce the vacuum box pressure to approximately 10 inches of mercury (5 psi, gauge).
      4) Examine the geomembrane through the viewing window for the presence of soap bubbles for a period of not less than ten seconds.
      5) All areas where soap bubbles appear shall be marked and repaired in accordance with repair procedures described in this specification.

3. Pressure Testing for penetrations or other difficult areas not accessible for vacuum testing.

   a. Equipment and Materials.

      1) Bicycle-type pump.
      2) Football-type needle for pumping.
      3) Pressure gauge.

   b. Procedures.

      1) Place needle into channel between welds, sealing off the other end of a seam. Pump pressure within seam to 30 psi and hold, recording pressure on pressure gauge.
      2) Hold pressure for at least 5 minutes. As long as the pressure does not drop more than 3psi, the seam passes.

      3) Before releasing pressure, cut the blockage at the far end of the seam tested. If the pressure releases, the seam can be accepted. If the pressure does not release, there is intermediate blockage and iterative testing is required to verify the actual length of seam tested.

4. Destructive Testing (performed by Installer).

   a. Location and Frequency of Testing.

      1) Collect destructive test samples at a minimum frequency of one test location per average **500** feet of seam length.
      2) Determine test locations during welding. Locations may be prompted by suspicion or excess crystallinity, contamination, offset welds, or suspected defect. QC Inspector will be responsible for choosing the locations.
      3) The QC Inspector may increase the test frequency based on marginal results.

   b. Sampling Procedures.

      1) Cut samples at locations designated by the QC Inspector as the welding progresses. Verify that destructive test results have been obtained before the geomembrane is covered by another material.
      2) QC Inspector will number each sample and mark sample number and location in compliance with the Construction QA/QC Plan.

   c. Immediately repair all holes in the geomembrane resulting from destructive test sampling. Repair in accordance with repair procedures described in this Section. Test the continuity of the repair in accordance with this Section.

d. Size of Sample: minimum 12 inches wide by 36 inches long with the seam centered lengthwise. Cut a one-inch wide strip from each end of the sample and test these for (shear and peel) in the field. Cut the remaining sample into three parts for distribution as follows:

1) One portion for Installer: 12 inches by 12 inches.
2) Two portions to QA Inspector for archive storage and testing: minimum 12 inches by 12 inches.

e. Field Testing (Performed by Installer)

1) Test the two, one-inch wide strips specified in paragraph d above by tensiometer for peel and shear, respectively.
2) Both test strips must meet peel and shear requirements for welded seams specified in this Section.
3) If any field test sample fails, follow failed test procedures outlined in this Section.

D. Failed Weld Procedures.

1. Follow these procedures when there is a destructive test failure. Procedures apply when test failure is determined by the QC Inspector or QA Inspector, or by field tensiometer. Follow one of the following two options:

a. First Option.

1) Reconstruct the seam between any two passing test locations. (Cannot extrusion weld flap.)

b. Second Option.

1) Trace the weld at least 10 feet minimum in both directions from the location of the failed test, or to the end of the weld.
2) Obtain a small sample at both locations for additional peal and shear tests.
3) Perform additional peal and shear tests.
4) If the additional peal and shear tests pass, then reconstruct the weld or cap between the two test sample locations that bracket the failed test location.
5) If any sample fails, then repeat the process to establish the zone in which the weld must be reconstructed.

E. Acceptable Welded Seams.

1. Bracketed by two locations from which samples have passed additional peal and shear tests.

2. For reconstructed seams exceeding 50 feet, a sample taken from within the reconstructed weld passes destructive testing.

F. Seams That Cannot Be Non-Destructively Tested: Perform the following:
   1. If the weld is accessible to testing equipment prior to final installation, non-destructively test the weld prior to final installation.
   2. If the weld cannot be tested prior to final installation, cap strip the weld. The welding and cap- stripping operations must be observed by the QC and QA Personnel for uniformity and completeness.

3.5 REPAIR PROCEDURES

A. Remove damaged geomembrane and replace with acceptable geomembrane materials if damage cannot be satisfactorily repaired.

B. Repair, removal, and replacement is at CONTRACTOR's expense if the damage results from CONTRACTOR's or Installer's activities or material defects.

C. Repair any portion of the geomembrane exhibiting a flaw, or failing a destructive or non-destructive test. Do not commence welding on liner until trial weld test sample passes trial test. Repair procedures available include:

   1. Patching: Used to repair large holes (over 3/8-inch diameter), tears, pinholes or other minor, localized flaws.

   2. Abrading: Used to repair small sections of seams.

   3. Spot welding or seaming: Used to repair small tears (less than 2 inches long), pinholes or other minor, localized flaws.

   4. Capping: Used to repair large lengths of failed seams.

   5. Removing the seam and replacing with a strip of new material.

D. In addition, satisfy the following procedures:

   1. Abrade geomembrane surfaces to be repaired (extrusion welds only) no more than one-half (1/2) hour prior to the repair.

   2. Clean and dry all surfaces at the time of repair.

   3. Extend patches or caps at least 6 inches beyond the edge of the defect, and round all corners of material to be patched and the patches to a radius of at least 3 inches.

E. Verification of repair:
   1. Number and log each patch repair.

   2. Non-destructively test each repair using methods specified in this Section.

   3. Additional destructive tests may be required at the discretion of QA Personnel.

4. Reconstruct repairs until tests indicate passing results.

3.6 CLEANUP

A. Clean up work area as work proceeds. Take particular care to ensure that no trash, tools, or other unwanted materials are trapped beneath the geomembrane and that scraps of geomembrane material are removed from the work area prior to completion of the installation.

3.7 GEOMEMBRANE ACCEPTANCE

A. CONTRACTOR retains all ownership and responsibility for the geomembrane until acceptance by OWNER.

B. OWNER will accept geomembrane installation when:
   1. All required documentation from the Manufacturer, Fabricator (if applicable), and Installer has been received and accepted.

   2. The geomembrane installation is finished.

   3. Test reports verifying completion of all field seams and repairs, including associated testing, is in accord with the Section.

   4. Written certification documents and drawings have been received by OWNER.

END OF SECTION

APPENDIX F

GEOTEX® 861 is a polypropylene, staple fiber, needlepunched nonwoven geotextile produced by Propex, and will meet the following Minimum Average Roll Values (MARV) when tested in accordance with the methods listed below. The fibers are needled to form a stable network that retains dimensional stability relative to each other. The geotextile is resistant to ultraviolet degradation and to biological and chemical environments normally found in soils.

GEOTEX 861 conforms to the property values listed below[1]. Propex performs internal Manufacturing Quality Control (MQC) tests that have been accredited by the Geosynthetic Accreditation Institute – Laboratory Accreditation Program (GAI-LAP). This product is NTPEP approved for AASHTO standards.

		MARV[2]	
PROPERTY	TEST METHOD	ENGLISH	METRIC
ORIGIN OF MATERIALS			
% U.S. Manufactured Inputs		100%	100%
% U.S. Manufactured		100%	100%
PHYSICAL			
Mass/ Unit Area	ASTM D-5261	8.0 oz/yd^2	271 g/m^2
Thickness	ASTM D-5199	90 mils	2.3 mm
MECHANICAL			
Tensile Strength (Grab)	ASTM D-4632	220 lbs	979 N
Elongation	ASTM D-4632	50%	50%
CBR Puncture	ASTM D-6241	575 lbs	2559 N
Trapezoidal Tear	ASTM D-4533	95 lbs	423 N
ENDURANCE			
UV Resistance % Retained at 500 hrs	ASTM D-4355	70%	70%
HYDRAULIC			
Apparent Opening Size (AOS)[3]	ASTM D-4751	80 US Std. Sieve	0.180 mm
Permittivity	ASTM D-4491	1.5 sec^{-1}	1.5 sec^{-1}
Permeability	ASTM D-4491	0.38 cm/sec	0.38 cm/sec
Water Flow Rate	ASTM D-4491	110 gpm/ft^2	4482 l/min/m^2
ROLL SIZES		15 ft x 300 ft	4.57 m x 91.5 m

NOTES:

1. The property values listed above are effective 04/2011 and are subject to change without notice.
2. Values shown are in weaker principal direction. Minimum average roll values (MARV) are calculated as the typical minus two standard deviations. Statistically, it yields a 97.7% degree of confidence that any samples taken from quality assurance testing will exceed the value reported.
3. Maximum average roll value.

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PRODUCT DATA SHEET

GSE PermaNet TRx Geonet

GSE PermaNet TRx is a biplanar geonet with two sets of round strands of which one set is oriented in the machine direction. This unique strand structure provides superior compressive creep resistance and ensures continuous flow performance over a broad range of conditions and long durations. GSE PermaNet is manufactured through a one-step extrusion process from prime quality high density polyethylene resins. This product is durable under rigorous environmental conditions and ideal for extremely demanding applications.

[*]

AT THE CORE:
A high flow geonet that provides durable performance over a broad range of conditions and is ideal for extremely high compressive stress applications.

Product Specifications

TEST PROPERTY	TEST METHOD	FREQUENCY	TYPICAL VALUE
Transmissivity[1], gal/min/ft (m^2/sec)	ASTM D 4716	1/540,000 ft^2	27 (5.8 X 10^{-3})
Compression Strength, lb/ft^2	ASTM D 6364	1/540,000 ft^2	40,000
Creep Reduction Factor	ASTM D 7361	1 per formulation	1.3@ 20,000 psf
Density, g/cm^3	ASTM D 1505	1/50,000 ft^2	0.94
Tensile Strength[2], lbs/inch	ASTM D 5035/7179	1/50,000 ft^2	151
Carbon Black Content, %	ASTM D 1603[3]/4218	1/50,000 ft^2	2.0
	NOMINAL ROLL DIMENSIONS		
Thickness, mil	ASTM D 5199	1/50,000 ft^2	300
Roll Width[4], ft			15
Roll Length[4], ft			200
Roll Area, ft^2			3,000

NOTES:
- [1] Gradient of 0.1, normal load of 25,000 psf, water at 70° F between steel plates for 15 minutes. This is an index value for quality control and quality assurance. Contact GSE for performance transmissivity data.
- [2] Machine direction
- [3] Modified
- [4] Roll widths and lengths have a tolerance of ±1%.

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Our commitment to innovation, our focus on quality and our industry expertise allow us the flexibility to collaborate with our clients to develop a custom, purpose-fit solution.

GSE ENVIRONMENTAL™

[DURABILITY RUNS DEEP] For more information on this product and others, please visit us at GSEworld.com, call 800.435.2008 or contact your local sales office

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Technical Data and Specifications
for

XR® Geomembranes

XR-3®
XR-5®
XR-3® PW

Industrial, Municipal and Potable Water Grade Geomembranes

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Product Application Chart

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6730 XR-5
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Seaman Corp. XR Geomembranes

Section 1 - Product Overview/Applications

- All XR Geomembrane products are classified as an Ethylene Interpolymer Alloy (EIA)
- XR-5 grade is high strength and chemically resistant for maximum resistance to high temperature, and broad chemical resistance, including acids, oils and methane
- XR-3 grade for moderate chemical resistant requirement applications such as stormwater and domestic wastewater
- NSF 61 approved XR-3 PW grade for potable water contact
- Heat weldable-thermal weldable for seams as strong as the membrane. Factory panels over 15,000 square feet (1400 sq meters) for less field seaming
- Stability is excellent, with low thermal expansion-contraction properties
- 30+ year application history

Product Application Chart

	XR-5			XR-3	XR-3 PW
	8130	**8138**	**6730**	**8228**	**8130**
High Puncture Resistance	X	X	X		X
UV Resistance	X	X	X	X	X
High Strength Applications	X	X	X		X
Floating Covers (Nonpotable)	X	X	X	X	
Diesel/Jet Fuel Containment	X	X	X		
Industrial Wastewater	X	X	X		
Stormwater	X	X	X	X	
Municipal/Domestic Wastewater	X	X	X	X	
Floating Diversion Baffles/Curtains	X		X		X
Potable Water					X
<-65 Deg F Applications	Contact Seaman Corp.				
Chemically Resistant Applications	X	X	X		

XR-5® is a registered trademark of Seaman Corporation
XR-3® is a registered trademark of Seaman Corporation
XR® is a registered trademark of Seaman Corporation

Section 2 - Physical Properties

Part 1- Material Specifications

Property	Test Method	8130 XR-5	8138 XR-5	6730 XR-5
Base Fabric Type Base Fabric Weight	ASTM D 751	Polyester 6.5 oz/yd² nominal (220 g/m² nominal)	Polyester 6.5 oz/yd² nominal (220 g/m² nominal)	Polyester 7 oz/yd² nominal (235 g/m² nominal)
Thickness	ASTM D 751	30 mils min. (0.76 mm min.)	40 mils nom. (1.0 mm nom.)	30 mils min. (0.76 mm min.)
Weight	ASTM D 751	30.0 +- 2 oz/sq yd (1017 +- 2 g/m²)	38.0 +- 2 oz/sq yd (1288 +- 70 g/m²)	30.0 +- 2 oz/sq yd (1017 +- 70 g/m²)
Tear Strength	ASTM D 751 Trap Tear	40/55 lbs min. (175/245 N min.)	40/55 lbs min. (175/245 N min.)	
Breaking Yield Strength	ASTM D 751 Grab Tensile	550/550 lbs min. (2,447/2,447 N min.)	550/550 lbs min. (2,447/2,447 N min.)	600/550 lbs. min. (2,670/2,447 N min.)
Low Temperature Resistance	ASTM D 2136 4 hrs-1/8" Mandrel	Pass @-30□F Pass @-35□C	Pass @-30□F Pass @-35□C	Pass @-30□F Pass @-35□C
Dimensional Stability	ASTM D 1204 100□C-1 Hr.	0.5% max. each direction	0.5% max. each direction	0.5% max. each direction
Hydrostatic Resistance	ASTM D 751 Procedure A	800 psi min. (5.51 MPa min.)	800 psi min. (5.51 MPa min.)	800 psi min. (5.51 MPa min.)
Blocking Resistance	ASTM D 751 180□F	#2 Rating max.	#2 Rating max.	#2 Rating max.
Adhesion-Ply	ASTM D 413 Type A	15 lbs./in. min. or film tearing bond (13 daN/5 cm min. or FTB)	15 lbs./in. min. or film tearing bond (13 daN/5 cm min. or FTB)	15 lbs./in. min. or film tearing bond (13 daN/5 cm min. or FTB)
Adhesion (minimum) Heat Welded Seam	ASTM D 751 Dielectric Weld	40 lbs./2in. RF weld min. (17.5 daN/5 cm min.)	40 lbs./2in. RF weld min. (17.5 daN/5 cm min.)	15 lbs./in. RF weld min. (15 daN/5 cm min.)
Dead Load Seam Strength	ASTM D 751, 4-Hour Test	Pass 220 lbs/in @70□F (Pass 980 N/2.54 cm @21□C) Pass 120 lbs/in @160□F (Pass 534 N/2.54 cm @70□C)	Pass 220 lbs/in @70□F (Pass 980 N/2.54 cm @21□C) Pass 120 lbs/in @160□F (Pass 534 N/2.54 cm @70□C)	
Bonded Seam Strength	ASTM D 751 Procedure A, Grab Test Method	550 lbs. min. (2,450 N min.)	550 lbs min. (2,450 N min.)	550 lbs. min. (2,560 N min.)

Abrasion Resistance	ASTM D 3389 H-18 Wheel 1 kg Load	2,000 cycles min. before fabric exposure, 50 mg/100 cycles max. weight loss	2,000 cycles min. before fabric exposure, 50 mg/100 cycles max. weight loss	2,000 cycles min. before fabric exposure, 50 mg/100 cycles max. weight loss
Weathering Resistance	Carbon-Arc ASTM G 153	8,000 hours min. with no appreciable changes or stiffening or cracking of coating	8000 hours min. with no appreciable change or stiffening or cracking of coating	8000 hours min. with no appreciable change or stiffening or cracking of coating
Water Absorption	ASTM D 471, Section 12 7 Days	0.025 kg/m² max. @70° F/21° C 0.14 kg/m² max at 212° F/100° C	0.025 kg/m² max. @70° F/21° C 0.14 kg/m² max at 212° F/100° C	0.025 kg/m² max. @70° F/21° C 0.14 kg/m² max at 212° F/100° C
Wicking	ASTM D 751	1/8" max (0.3 cm max)	1/8" max. (0.3 cm max.)	1/8" max. (0.3 cm max.)
Bursting Strength	ASTM D 751 Ball Tip	750 lbs. min. (3,330 N min.)	750 lbs. min. (3,330 N min.)	750 lbs. min. (3,330 N min.)
Puncture Resistance	ASTM D 4833	275 lbs. min. 1,200 N min.	275 lbs. min. 1,200 N min.	275 lbs. min. 1,200 N min.
Coefficient of Thermal Expansion/ Contraction	ASTM D 696	8×10^{-6} in/in/°F max. (1.4×10^{-5} cm/cm/°C max.)	8×10^{-6} in/in/°F max. (1.4×10^{-5} cm/cm/°C max.)	8×10^{-6} in/in/°F max. (1.4×10^{-5} cm/cm/°C max.)
Environmental/Chemical Resistant Properties		See Chemical Resistance Table, Page 8	See Chemical Resistance Table, Page 8	See Chemical Resistance Table, Page 8
Puncture Resistance	FED-STD-101C Method 2031	350 lbs. (approx.)	350 lbs. (approx.)	
Cold Crack	ASTM D 2136 4 Hrs, 1/8" Mandrel	Pass at -30° F/-34° C	Pass @-30° F/-34° C	Pass @-30° F/-34° C

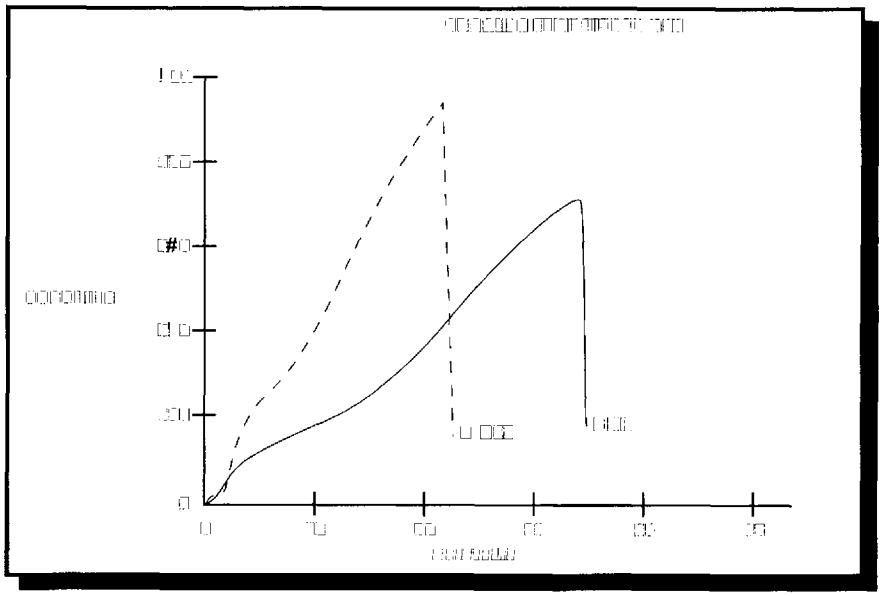
Part 1- Material Specifications (cont.)

Property	Test Method	8130 XR-3 PW	8228 XR-3
Base Fabric Type Base Fabric Weight	ASTM D 751	Polyester 6.5 oz/yd² nominal (220 g/m² nominal)	Polyester 3.0 oz/yd² nominal (100 g/m² nominal)
Thickness	ASTM D 751	30 mils min. (0.76 mm min.)	30 mils min. (0.76 mm min.)
Weight	ASTM D 751	30.0 +- 2 oz./sq. yd. (1017 +- 70 g/sq. m)	28.0 +- 2 oz./sq. yd. (950 +- 70 g/sq. m)
Tear Strength	ASTM D 751 Trap Tear	40/55 lbs. min. (175/245 N min.)	30/30 lbs. nom. (133/133 N nom.)
Breaking Yield Strength	ASTM D 751 Grab Tensile	550/550 lbs. min. (2,447/2447 N min.)	250/200 lbs. min. (1,110/890 N min.)
Low Temperature Resistance	ASTM D 2136 4hrs-1/8" Mandrel	Pass @-30□F (Pass @-35□C)	Pass @-25□F (Pass @-32□C)
Dimensional Stability	ASTM D 1204 100□C-1 hr.	0.5% max. each direction	5% max. each direction
Hydrostatic Resistance	ASTM D 751 Method A	800 psi min. (5.51 MPa min.)	300 psi min. (2.07 MPa min.)
Blocking Resistance	ASTM D 751 180□F	#2 Rating max.	#2 Rating max.
Adhesion-Ply	ASTM D 413 Type A	15 lbs./in. *min. or film* tearing bond (13 daN/5 cm min. or FTB)	12 lbs./in. (approx.) (10 daN/5 cm approx.)
Adhesion- Heat Welded Seam	ASTM D 751 Dielectric Weld	40 lbs./2in. min. (17.5 daN/5 cm min.)	10 lbs./in min. (9 daN/5 cm min.)
Dead Load Seam Strength	ASTM D 751, 4-Hour Test	Pass 220 lbs/in. @70□F (Pass 980 N/2.54 cm @21□C) Pass 120 lbs/in. @160□F (Pass 534 N/2.54 cm @70□C)	Pass 100 lbs/in @70□F (Pass 445 N @21□C) Pass 50 lb @160□F (Pass 220 N @70□C)
Bonded Seam Strength	ASTM D 751 Procedure A, Grab Test Method	550 lbs. min. (2,450 N min.)	250 lbs. (approx.) (1,112 N min.)

Abrasion Resistance	ASTM D 3389 H-18 Wheel 1 kg Load	2000 cycles min. before fabric exposure, 50 mg/100 cycles max. weight loss	2000 cycles min.
Weathering Resistance	ASTM G 153	8000 hours min. with no appreciable change or stiffening or cracking of coating	8000 hours min.
Water Absorption	ASTM D 471, Section 12 7 Days	0.025 kg/m² max. @70 □F/21□C 0.14 kg/m² max @212 □F/100 □C	0.05 kg/m² max. @70 □F/21□C (approx.) 0.28 kg/m² max. @212□F/100 □C (approx.)
Wicking	ASTM D 751	1/8" max. (0.3 cm max.)	1/8 □max (0.3 cm max.)
Bursting Strength	ASTM D 751 Ball Tip	750 lbs. min. (3330 N min.)	350 lbs. (approx.) (1557 N min.)
Puncture Resistance	ASTM D 4833	275 lbs. min. 1200 N min.	50 lb typ. (225 N typ.)
Coefficient of Thermal Expansion/ Contraction	ASTM D 696	8 x 10^{-6} in/in/□F max. (1.4 x 10^{-5} cm/cm/□C max.)	8 x 10^{-6} in/in/□F max. (approx.) (1.4 x 10^{-5} cm/cm/□C max. approx.)
Environmental/Chemical Resistant Properties	ASTM D 741 7-Day Total Immersion With Exposed Edges	NSF 61 approved for potable water	Crude oil 5% max. weight gain Diesel fuel 5% max. weight gain
Puncture Resistance	FTMS 101C Method 2031	350 lbs. (approx.)	205 lbs. (approx.)
Tongue Tear	ASTM D 751		50 lbs. (approx.)

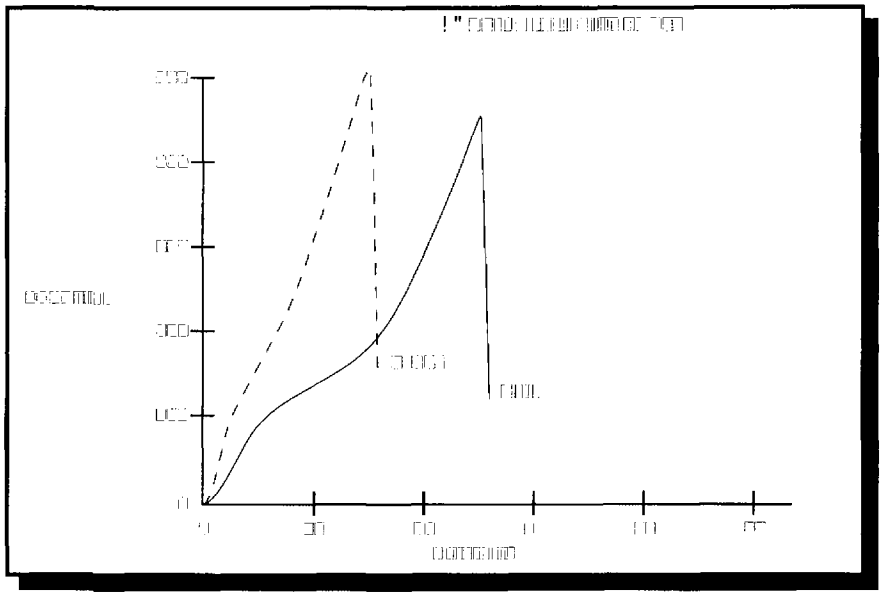
Part 2 - Elongation Properties Test

8130 XR-5



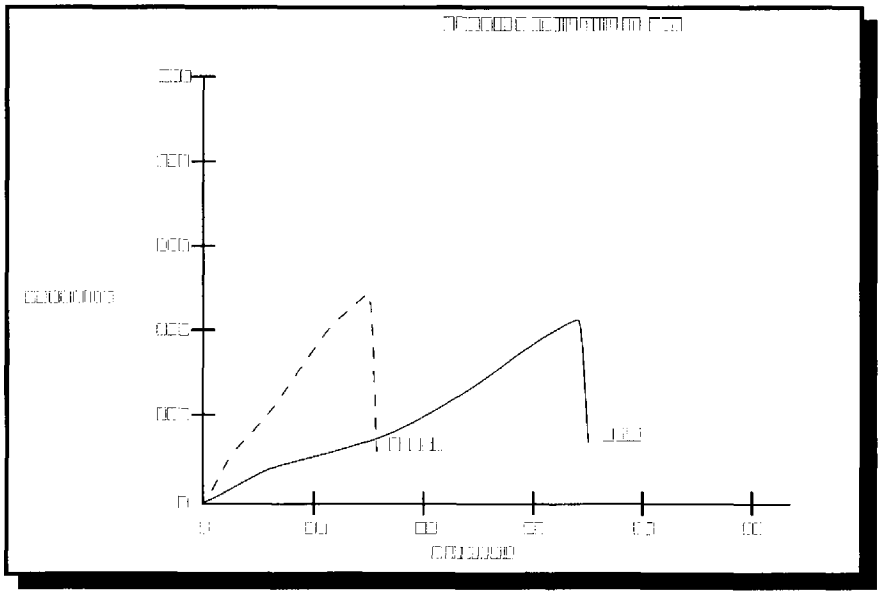
Part 2 - Elongation Properties Test

6730 XR-5



Part 2 - Elongation Properties Test

8228 XR-3



Section 3 - Chemical/Environmental Resistance

Part 1 - XR-5® Fluid Resistance Guidelines

The data below is the result of laboratory tests and is intended to serve only as a guide. No performance warranty is intended or implied. The degree of chemical attack on any material is governed by the conditions under which it is exposed. Exposure time, temperature, and size of the area of exposure usually varies considerably in application, therefore, this table is given and accepted at the user's risk. Confirmation of the validity and suitability in specific cases should be obtained. Contact a Seaman Corporation Representative for recommendation on specific applications.

When considering XR-5 for specific applications, it is suggested that a sample be tested in actual service before specification. Where impractical, tests should be devised which simulate actual service conditions as closely as possible.

EXPOSURE	RATING	EXPOSURE	RATING
AFFF	A	JP-4 Jet Fuel	A
Acetic Acid (5%)	B	JP-5 Jet Fuel	A
Acetic Acid (50%)	C	JP-8 Jet Fuel	A
Ammonium Phosphate	T	Kerosene	A
Ammonium Sulfate	T	Magnesium Chloride	T
Antifreeze (Ethylene Glycol)	A	Magnesium Hydroxide	T
Animal Oil	A	Methanol	A
Aqua Regia	X	Methyl Alcohol	A
ASTM Fuel A (100% Iso-Octane)	A	Methyl Ethyl Ketone	X
ASTM Oil #2 (Flash Pt. 240° C)	A	Mineral Spirits	A
ASTM Oil #3	A	Naphtha	A
Benzene	X	Nitric Acid (5%)	B
Calcium Chloride Solutions	T	Nitric Acid (50%)	C
Calcium Hydroxide	T	Perchloroethylene	C
20% Chlorine Solution	A	Phenol	X
Clorox	A	Phenol Formaldehyde	B
Conc. Ammonium Hydroxide	A	Phosphoric Acid (50%)	A
Corn Oil	A	Phosphoric Acid (100%)	C
Crude Oil	A	Phthalate Plasticizer	C
Diesel Fuel	A	Potassium Chloride	T
Ethanol	A	Potassium Sulphate	T
Ethyl Acetate	C	Raw Linseed Oil	A
Ethyl Alcohol	A	SAE-30 Oil	A
Fertilizer Solution	A	Salt Water (25%)	B
#2 Fuel Oil	A	Sea Water	A
#6 Fuel Oil	A	Sodium Acetate Solution	T
Furfural	X	Sodium Bisulfite Solution	T
Gasoline	B	Sodium Hydroxide (60%)	A
Glycerin	A	Sodium Phosphate	T
Hydraulic Fluid- Petroleum Based	A	Sulphuric Acid (50%)	A
Hydraulic Fluid- Phosphate		Tanic Acid (50%)	A
Ester Based	C	Toluene	C
Hydrocarbon Type II (40% Aromatic)	C	Transformer Oil	A
Hydrochloric Acid (50%)	A	Turpentine	A
Hydrofluoric Acid (5%)	A	Urea Formaldehyde	A
Hydrofluoric Acid (50%)	A	UAN	A
Hydrofluosilicic Acid (30%)	A	Vegetable Oil	A
Isopropyl Alcohol	T	Water (200°F)	A
Ivory Soap	A	Xylene	X
Jet A	A	Zinc Chloride	T

Ratings are based on visual and physical examination of samples after removal from the test chemical after the samples of Black XR-5 were immersed for 28 days at room temperature. Results represent ability of material to retain its performance properties when in contact with the indicated chemical.

Rating Key:
A – Fluid has little or no effect
B – Fluid has minor to moderate effect
C – Fluid has severe effect
T – No data - likely to be acceptable
X – No data - not likely to be acceptable

Vapor Transmission Data

Tested according to ASTM D814-55 Inverted Cup Method

Perhaps a more meaningful test is determination of the diffusion rate of the liquid through the membrane. The vapor transmission rate of Style 8130 XR-5® to various chemicals was determined by the ASTM D814-55 inverted cup method. All tests were run at room temperature and results are shown in the table.

Chemical	8130 XR-5 Black g/hr/m2
Water	0.11
#2 Diesel Fuel	0.03
Jet A	0.11
Kerosene	0.15
Hi-Test Gas	1.78
Ohio Crude Oil	0.03
Low-Test Gas	5.25
Raw Linseed Oil	0.01
Ethyl Alcohol	0.23
Naphtha	0.33
Perchlorethylene	38.58
Hydraulic Fluid	0.006
100% Phosphoric Acid	7.78
50% Phosphoric Acid	0.43
Ethanol (E-96)	0.65
Transformer Oil	0.005
Isopropyl Alcohol	0.44
JP4 (E-96)	0.81
JP8 (E-96)	0.42
Fuel B (E-96)	6.28
Fuel C (E-96)	7.87

Note: The tabulated values are measured Vapor Transmission Rates (VTR). Normal soil testing methods to determine permeability are impractical for synthetic membranes. An "equivalent hydraulic" permeability coefficient can be calculated but is not a direct units conversion. Contact Seaman Corporation for additional technical information.

Seam Strength

Style 8130 XR-5 Black Seam Strength After Immersion

Two pieces of Style 8130 were heat sealed together (seam width 1 inch overlap) and formed into a bag. Various oils and chemicals were placed in the bags so that the seam area was entirely covered. After 28 days at room temperature, the chemicals were removed and one inch strips were cut across the seam and the breaking strength immediately determined. Results are listed below.

Chemical	Seam Strength
None	340 Lbs. Fabric Break- No Seam Failure
Kerosene	355 Lbs. Fabric Break- No Seam Failure
Ohio Crude Oil	320 Lbs. Fabric Break- No Seam Failure
Hydraulic Fluid- Petroleum Based	385 Lbs. Fabric Break- No Seam Failure
Toluene	0 Lbs. Adhesion Failure
Naphtha	380 Lbs. Fabric Break- No Seam Failure
Perchloroethylene	390 Lbs. Fabric Break- No Seam Failure

Even though 1-inch overlap seams are used in the tests to study the accelerated effects, it is recommended that XR-5 be used with a 2-inch nominal overlap seam in actual application. In some cases where temperatures exceed 160°F and the application demands extremely high seam load, it may be necessary to use a wider width seam.

Long Term Seam Adhesion

11 Years Immersion
ASTM D 751
Lbs./In.

Seam samples of 8130 XR-5® were dielectrically welded together and totally immersed in the liquids for 11 years. The samples were taken out, dried for 24 hours and visually observed for any signs of swelling, cracking, stiffening or degradation of the coating. The coating showed no appreciable degradation and no stiffening, swelling, cracking or peeling.

The adhesion, or resistance to separation of the coating from the base cloth, was then measured by ASTM D 751. Results show 8130 XR-5 maintains seam strength over this long period (11 years).

	Control	Crude Oil	JP-4 Jet Fuel	Diesel Fuel	Kerosene	Naphtha
8130 XR-5	20+	18	33	25	40	33*

Values in lbs./in.

*The naphtha sample was sticky.

We believe this information is the best currently available on the subject. We offer it as a suggestion in any appropriate experimentation you may care to undertake. It is subject to revision as additional knowledge and experience are gained. We make no guarantee of results and assume no obligation or liability whatsoever in connection with this information.

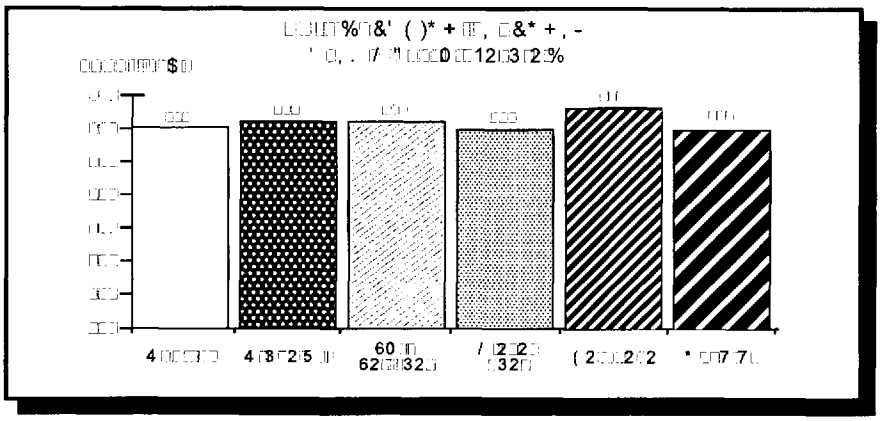
Fuel Compatibility - Long Term Immersion

Test: Samples of 8130 XR-5® Black were immersed in Diesel Fuel, JP-4 Jet Fuel, Crude Oil, Kerosene, and Naphtha for 6 1/2 years.

The samples were then taken out of the test chemicals, blotted and dried for 24 hours. The samples were observed for blistering, swelling, stiffening, cracking or delamination of the coating from the fiber.

Results: It was found in all cases that the 8130 XR-5, after immersion for six years, maintained its strength and there was no evidence of blistering, swelling, stiffening, cracking or delamination.

The strip tensile strength, or breaking strength, of the samples was measured after six years of immersion and the following are the results.



XR-3 Chemical Resistance Statement (Summary)

XR-3® is recommended for moderate chemical resistant applications such as stormwater and municipal wastewater and is not recommended for prolonged contact with pure solutions. XR-3 PW® membranes are recommended only for contact with drinking water and are resistant to low levels of chlorine found in drinking water. XR-5 has a broad range of chemical resistance which is detailed in this section.

Part 2: XR-5® Comparative Chemical Resistance

Chemical Resistance Chart

Comparative Chemical Resistance

	XR-5	HDPE	PVC	Hypalon	Polypropylene
Kerosene	A	B	C	C	C
Diesel Fuel	A	A	C	C	C
Acids (General)	A	A	A	B	A
Naphtha	A	A	C	B	C
Jet Fuels	A	A	C	B	C
Saltwater, 160° F	A	A	C	B	A
Crude Oil	A	B	C	B	C
Gasoline	B	B	C	C	C

A= Excellent B= Moderate C= Poor

Source: Manufacturer's Literature

XR-5 data based on conditions detailed in Section 3, Part 1.

Part 3: Weathering Resistance

Accelerated Weathering Test

XR-5 has been tested in the carbon arc weatherometer for over 10,000 hours of exposure and in the Xenon weatherometer for over 12,000 hours of exposure. The sample showed no loss in flexibility and no significant color change. Based on field experience of Seaman Corporation products and similar weatherometer exposure tests, XR-5 should have an outdoor weathering life significantly longer than competitive geomembranes, particularly in tropical or subtropical applications.

EMMAQUA Testing: ASTM E-838-81 was performed on a modified form of XR-5, FiberTite, used in the single-ply roofing industry. After 3 million Langleys in Arizona, no signs of degradation were noted with no evidence of cracking, blistering, swelling or adhesion delamination failure of the coating.

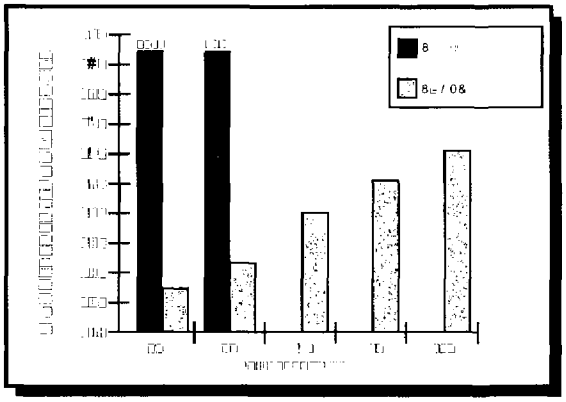
Natural Exposure

After over 17 years as a holding basin at a large oil company in the Texas desert, XR-5 showed no signs of environmental stress cracking, thermal expansion/contraction, or low yield strength problems. Temperature ranges from near zero to over 100° F.

In service approximately 17 years in a solar pond application at a research facility in Ohio, UV exposed samples, as well as immersed samples, retained over 90% of the tensile strength. Examination of the material determined there was little effect on the coating compound. The solar pond was exposed to temperatures from below zero to over 100° F.

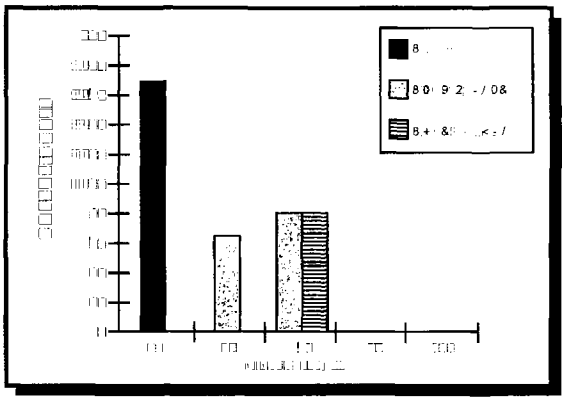
XR5 was exposed for 12½ years in Sarasota, Florida, on a weathering rack, facing the southern direction at 45°. No significant color loss, cracking, crazing, blistering, or adhesion delamination failure of the coating was noted.

XR-5/HDPE Comparative Properties

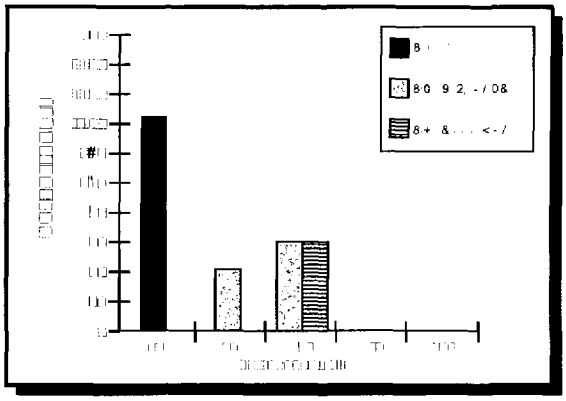


Puncture Resistance

1. ASTM D 751, Screwdriver Tip, 45° Angle (Room Temperature) Puncture Resistance, XR5 vs. HDPE



2. FED-STD-101C Method 2065 (Room Temperature)*



3. FED-STD-101C Method 2065 (70°C)*

* Data provided by E.I. DuPont de Nemours & Co. Wilmington, Delaware

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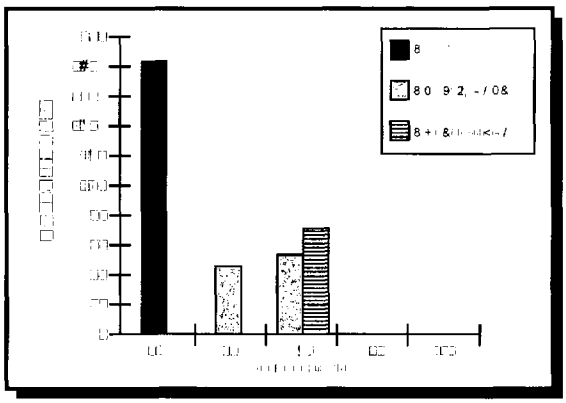
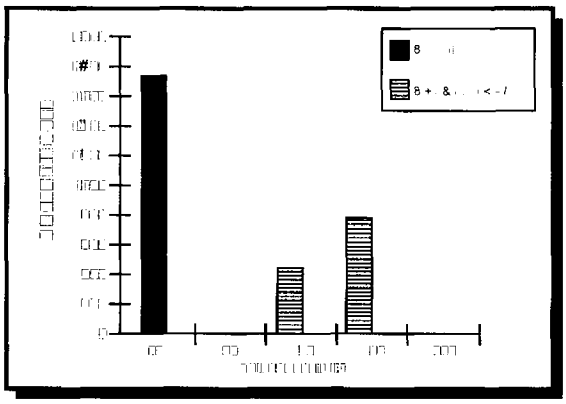
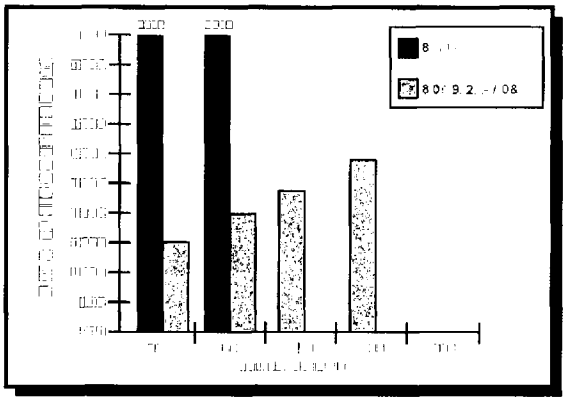


4. FED-STD-101C Method 2065 (100°C)*



5. ASTM D 751 Ball Burst Puncture



Yield Strength

1. Yield Strength, XR-5 vs. HDPE

Test Method: Grab Tensile, ASTM D 751, 70° C

* Data provided by E.I. DuPont de Nemours & Co. Wilmington, Delaware

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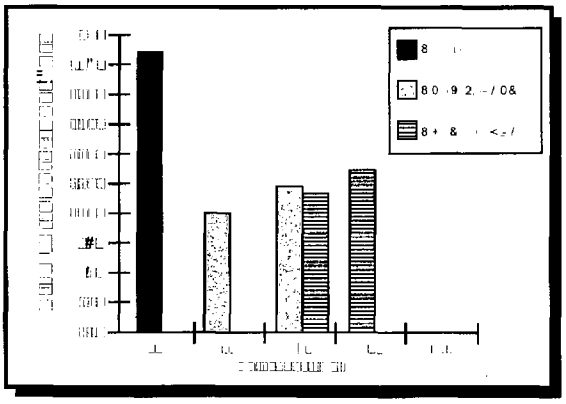
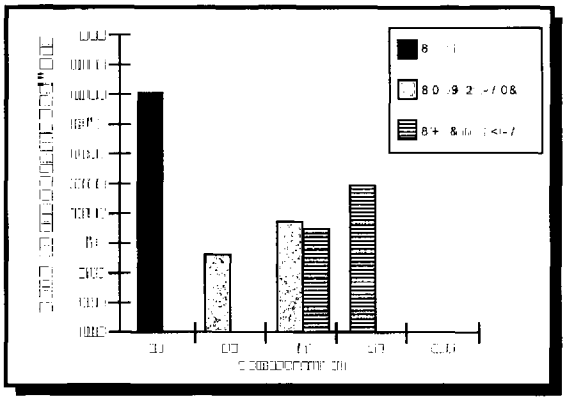
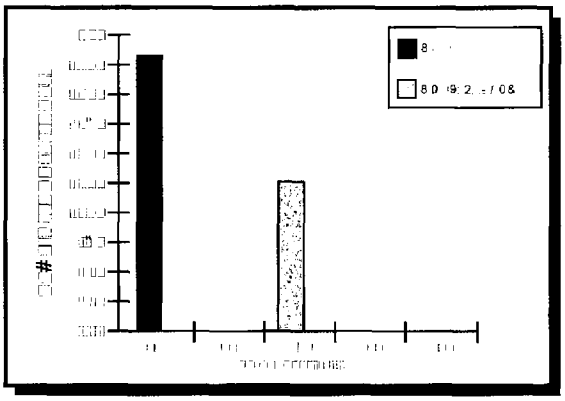


2. Strip Tensile, ASTM D 751, Room Temperature*



3. Strip tensile, ASTM D 751, 70°C*



Tear Strength

1. Tongue Tear (8" x 10" Specimens), ASTM D 751, Room Temperature*

* Data provided by E.I. DuPont de Nemours & Co. Wilmington, Delaware

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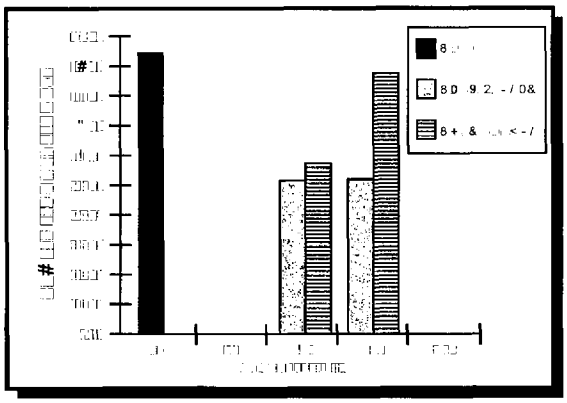
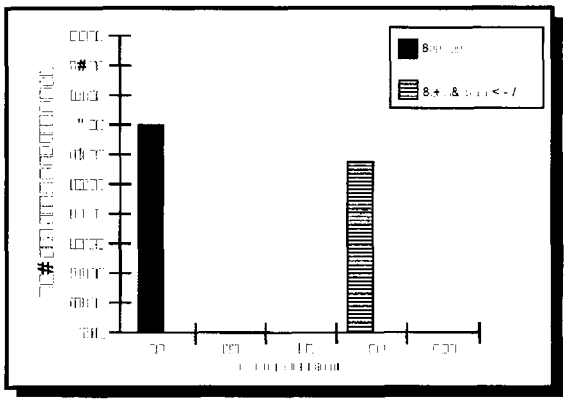


1. Graves Tear, ASTM D 624, Die C, Room Temperature*

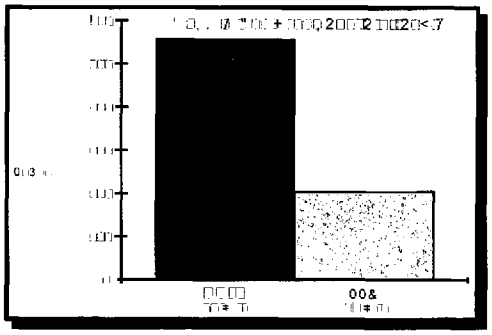


2. Graves Tear, ASTM D 624, Die C, 70°C*

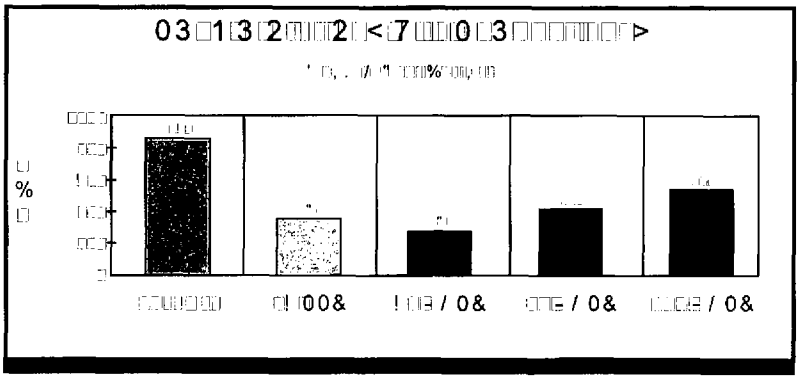
* Data provided by E.I. DuPont de Nemours & Co. Wilmington, Delaware

GSE is a registered trademark of GSE Lining Technology, Inc.

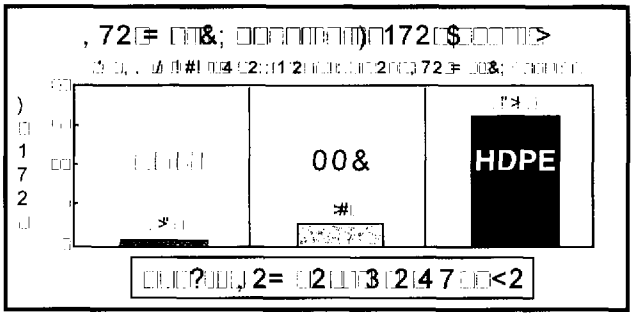
Grab Strength – XR-5® vs. Polypropylene Tensile



Puncture Strength Comparison



Coated Fabric Thermal Stability



Specification For Geomembrane Liner

(Sample specification: 8130 XR-5®. For other product specifications, go to www.xr-5.com)

General

1.01 Scope Of Work

Furnish and install flexible membrane lining in the areas shown on the drawings. All work shall be done in strict accordance with the project drawings, these specifications and membrane lining fabricator's approved shop drawings.

Geomembrane panels will be supplied sufficient to cover all areas, including appurtenances, as required in the project, and shown on the drawings. The fabricator/installer of the liner shall allow for shrinkage and wrinkling of the field panels.

1.02 Products

The lining material shall be 8130 XR-5 as manufactured by Seaman Corporation (1000 Venture Boulevard, Wooster, OH 44691; 330-262-1111), with the following physical specifications:

Base- (Type)	Polyester
Fabric Weight (ASTM D 751)	6.5 oz./sq. yd.
Finished Coated Weight (ASTM D 751)	30 ± 2 oz./sq. yd.
Trapezoid Tear (ASTM D 751)	40/55 lbs. min.
Grab Yield Tensile (ASTM D 751, Grab Method Procedure A)	550/550 lbs. min.
Elongation @ Yield (%)	20% min.
Adhesion- Heat Seam (ASTM D 751, Dielectric Weld)	40 lbs./2in. weld min.
Adhesion- Ply (ASTM D 413, Type A)	15 lbs./in. or film tearing bond
Hydrostatic Resistance (ASTM D 751, Method A)	800 psi min.
Puncture Resistance (ASTM D 4833)	275 lbs. min.
Bursting Strength (ASTM D 751 Ball Tip)	750 lbs. min.
Dead Load (ASTM D 751) Room Temperature	220 lbs. min.
(2" overlap seam, 4 hours) 160°F	120 lbs. min.
Bonded Seam Strength (ASTM D 751 Grab Test Method, Procedure A)	575 lbs. min.
Low Temperature (ASTM D 2136, 4 hours- 1/8" Mandrel)	Pass @ -30°F
Weathering Resistance ASTM G 153 Carbon Arc	8,000 hours min. With no appreciable changes or stiffening or cracking of coating
Dimensional Stability (ASTM D 1204, 212°F 1 Hour, Each Direction)	0.5% max.
Water Absorption (ASTM D 471, 7 Days)	0.025 kg/m² max. @ 70°F 0.14 kg/m² max. @ 212°F
Abrasion Resistance ASTM D 3389,	2000 cycles before fabric exposure;
H-18 Wheel, 1000 g load	50 mg/100 cycles max. wgt. Loss
Coefficient of Thermal Expansion/Contraction (ASTM D 696)	8×10^{-6} in/in/°F max.

1.03 Submittals

The fabricator of panels used in this work shall prepare shop drawings with a proposed panel layout to cover the liner area shown in the project plans. Shop drawings shall indicate the direction of factory seams and shall show panel sizes consistent with the material quantity requirements of 1.01.

Details shall be included to show the termination of the panels at the perimeter of lined areas, the methods of sealing around penetrations, and methods of anchoring.

Placement of the lining shall not commence until the shop drawings and details have been approved by the owner, or his representative.

1.04 Factory Fabrication
The individual XR-5* liner widths shall be factory fabricated into large sheets custom designed for this project so as to minimize field seaming. The number of factory seams must exceed the number of field seams by a factor of at least 10.

A two-inch overlap seam done by heat or RF welding is recommended. The surface of the welded areas must be dry and clean. Pressure must be applied to the full width of the seam on the top and bottom surface while the welded area is still in a melt-type condition. The bottom welding surface must be flat to insure that the entire seam is welded properly. Enough heat shall be applied in the welding process that a visible bead is extruded from both edges being welded. The bead insures that the material is in a melt condition and a successful chemical bond between the two surfaces is accomplished.

Two-inch overlapped seams must withstand a minimum of 240 pounds per inch width dead load at 70° F. and 120 pounds per inch width at 160° F. as outlined in ASTM D 751. All seams must exceed 550 lbs. bonded seam strength per ASTM D 751 Bonded Seam Strength Grab Test Method, Procedure A.

1.05 Inspection And Testing Of Factory Seams
The fabricator shall monitor each linear foot of seam as it is produced. Upon discovery of any defective seam, the fabricator shall stop production of panels used in this work and shall repair the seam, and determine and rectify the cause of the defect prior to continuation of the seaming process.

The fabricator must provide a Quality Control procedure to the owner or his representative which details his method of visual inspection and periodic system checks to ensure leak-proof factory fabrication.

1.06 Certification and Test Reports
Prior to installation of the panels, the fabricator shall provide the owner, or his representative, with written certification that the factory seams were inspected in accordance with Section 1.05.

1.07 Panel Packaging and Storage
Factory fabricated panels shall be accordian-folded, or rolled, onto a sturdy wooden pallet designed to be moved by a forklift or similar equipment. Each factory fabricated panel shall be prominently and indelibly marked with the panel size. Panels shall be protected as necessary to prevent damage to the panel during shipment.

Panels which have been delivered to the project site shall be stored in a dry area.

1.08 Qualifications of Suppliers
The fabricator of the lining shall be experienced in the installation of flexible membrane lining, and shall provide the owner or his representative with a list of not less than five (5) projects and not less than 500,000 square feet of successfully installed XR-5 synthetic lining. The project list shall show the name, address, and telephone number of an appropriate party to contact in each case. The manufacturer of the sheet goods shall provide similar documentation with a 10 million square foot minimum, with at least 5 projects demonstrating 10+ years service life.

The installer shall provide similar documentation to that required by the fabricator.

1.09 Subgrade Preparation By Others
Lining installation shall not begin until a proper base has been prepared to accept the membrane lining. Base material shall be free from angular rocks, roots, grass and vegetation. Foreign materials and protrusions shall be removed, and all cracks and voids shall be filled and the surface made level, or uniformly sloping as indicated

on the drawings. The prepared surface shall be free from loose earth, rocks, rubble and other foreign matter. Generally, no rock or other object larger than USCS sand (SP) should remain on the subgrade in order to provide an adequate safety factor against puncture. Geotextiles may be used to compensate for irregular subgrades. The subgrade shall be uniformly compacted to ensure against settlement. The surface on which the lining is to be placed shall be maintained in a firm, clean, dry and smooth condition during lining installation.

1.10 Lining Installation
Prior to placement of the liner, the installer will indicate in writing to the owner or his representative that he believes the subgrade to be adequately prepared for the liner placement.

The lining shall be placed over the prepared surface in such a manner as to assure minimum handling. The sheets shall be of such lengths and widths and shall be placed in such a manner as to minimize field seaming.

In areas where wind is prevalent, lining installation should be started at the upwind side of the project and proceed downwind. The leading edge of the liner shall be secured at all times with sandbags or other means sufficient to hold it down during high winds.

Sandbags or rubber tires may be used as required to hold down the lining in position during installation. Materials, equipment or other items shall not be dragged across the surface of the liner, or be allowed to slide down slopes on the lining. All parties walking or working upon the lining material shall wear soft-sole shoes.

Lining sheets shall be closely fit and sealed around inlets, outlets and other projections through the lining. Lining to concrete seals shall be made with a mechanical anchor, or as shown on the drawings. All piping, structures and other projections through the lining shall be sealed with approved sealing methods.

1.11 XR-5 Field Seaming
All requirements of Section 1.04 and 1.05 apply. A visible bead should be extruded from the hot air welding process.

Field fabrication of lining material will not be allowed.

1.12 Inspection
All field seams will be tested using the Air Lance Method. A compressed air source will deliver 55 psi minimum to a 3/16 inch nozzle. The nozzle will be directed to the lip of the field seam in a near perpendicular direction to the length of the field seam. The nozzle will be held 4 inches maximum from the seam and travel at a rate not to exceed 40 feet per minute. Any loose flaps of 1/8" or greater will require a repair.

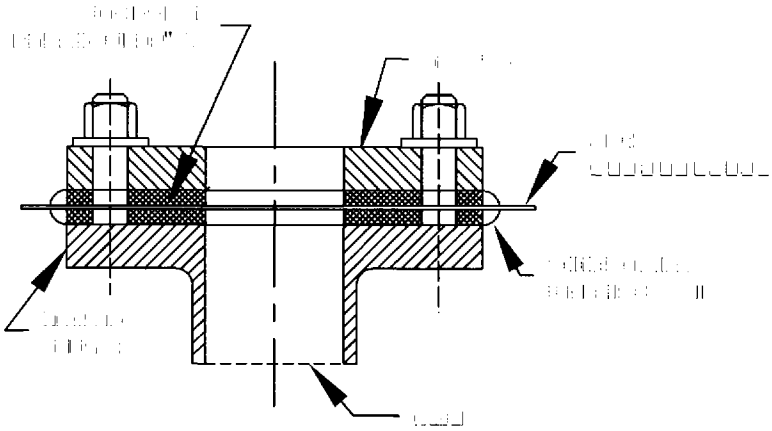
Alternatively all field seams should also be inspected utilizing the Vacuum Box Technique as described in Standard Practice for Geomembrane Seam Evaluation by Vacuum Chamber (ASTM D 5641-94 (2006)), using a 3 to 5 psi vacuum pressure. All leaks shall be repaired and tested.

All joints, on completion of work, shall be tightly bonded. Any lining surface showing injury due to scuffing, penetration by foreign objects, or distress from rough subgrade, shall as directed by the owner or his representative be replaced or covered, and sealed with an additional layer of lining of the proper size, in accordance with the patching procedure.

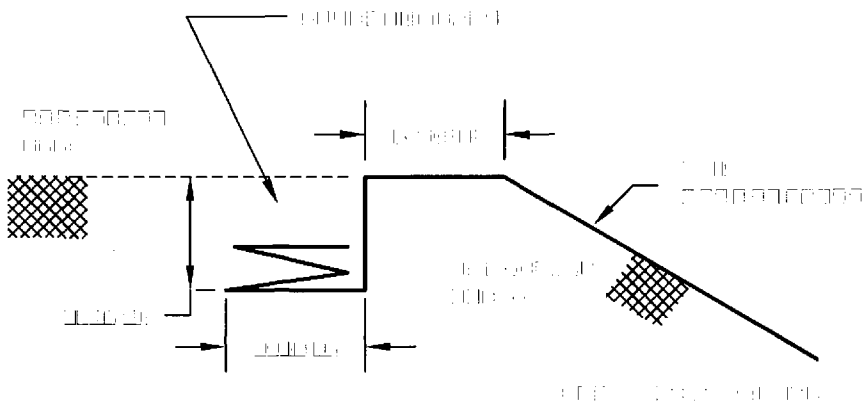
1.13 Patching
Any repairs to the lining shall be patched with the lining material. The patch material shall have rounded corners and shall extend a minimum of four inches (4") in each direction from the damaged area.

Seam repairs or seams which are questionable should be cap stripped with a 1" wide (min.) strip of the liner material. The requirements of Section 1.11 apply to this cap stripping.

1.14 Warranty
The lining material shall be warranted on a pro-rated basis for 10 years against both weathering and chemical compatibility in accordance with Seaman Corporation warranty for XR-5® Style 8130. A test immersion will be performed by the owner and the samples evaluated by the manufacturer. Workmanship of installation shall be warranted for one year on a 100% basis.



FLANGE CONNECTION
TO
PIPE SECTION



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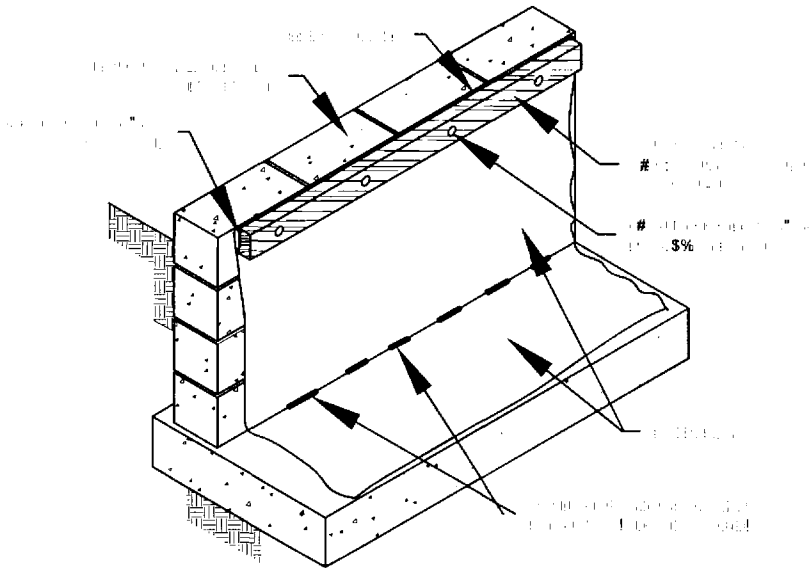
ELEVATION VIEW
TYPICAL ANCHOR DETAILS
XR-5 LINER



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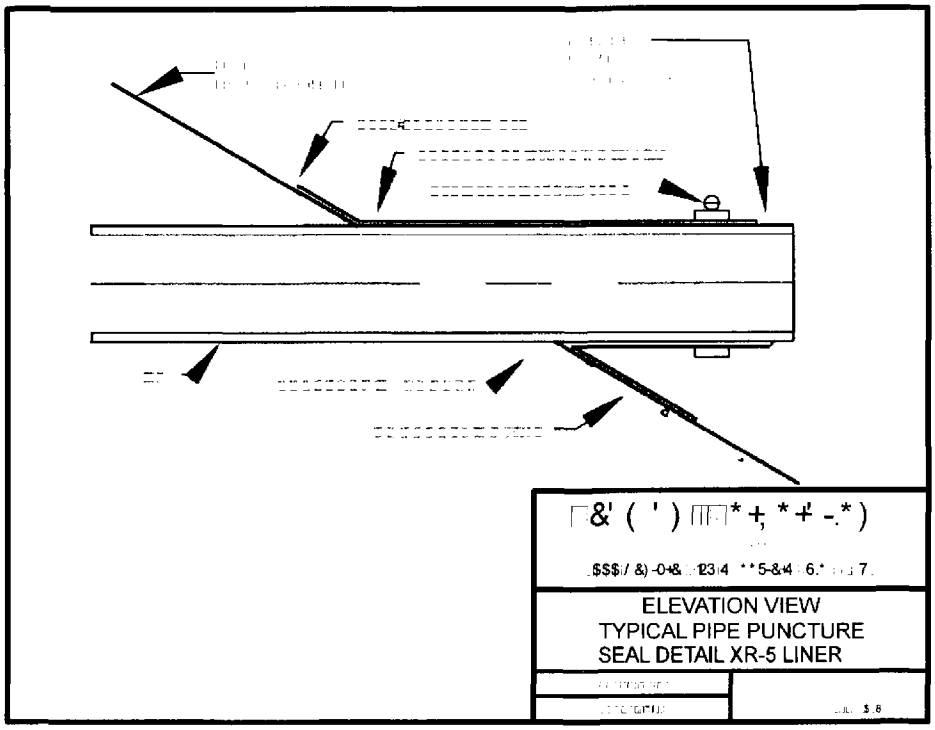
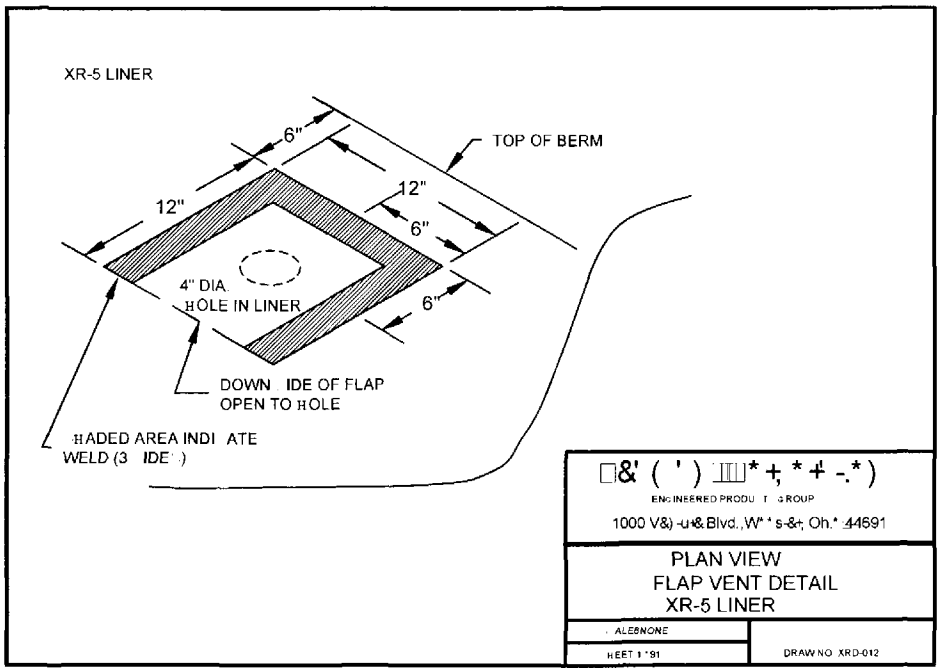
ANCHORING DETAIL
XR-5 LINER TO FIXED WALL


ELEVATION VIEW
TYPICAL PIPE PUNCTURE
SEAL DETAIL XR-5 LINER


XR-5 LINER
6"
12"
TOP OF BERM
12"
6"
4" DIA.
HOLE IN LINER
6"
DOWN IDE OF FLAP
OPEN TO HOLE
HADED AREA INDI ATE
WELD (3 IDE)
ENGINEERED PRODU T GROUP
1000 V&) -u&Blvd.,W* s-&-; Oh.* 44691
PLAN VIEW
FLAP VENT DETAIL
XR-5 LINER
ALEBNONE
HEET 1 '91
DRAW NO XRD-012

Section 6 - Warranty Information

Warranty

XR-5® is offered with Seaman Corporation standard warranty which addresses weathering and chemical compatibility for a 10-year period. A test immersion is required with subsequent testing and approval by Seaman Corporation.

Instructions for XR-5 Test Immersions and Warranty Requests

1. Completely immerse six Style 8130 XR-5 samples (8-1/2" x 11" size) in the liquid to be contained.
2. At the end of approximately thirty days, retrieve three of the samples. The samples should be rinsed with fresh water and dried.
3. Send the three samples to:

   Attn: Geomembrane Department
   Seaman Corporation
   1000 Venture Blvd.
   Wooster, OH 44691

4. Keep the other three samples immersed until further notice in case longer immersion data is required.
5. Complete and return the information form on the liner application.

8228 XR-3® and all PW Geomembranes are offered with a standard 10-year warranty for weathering. The attached information form should be completed.

XR® Membrane Application and Utilization Form

Installation Owner and Address:

_____
_____
_____
_____
_____
_____
_____

Physical Location of Installation:

_____
_____
_____
_____
_____
_____

Expected Date of Installation: _____

Expected Beginning Date of Service: _____

Description of Application:
(Example: impoundment used to contain brine on an emergency basis.)

_____
_____
_____
_____
_____

Physical Features of Application:
(Example: 1.3 million gallon earthen impoundment with overall top dimensions of 160′ x 160′ with 3:1 slopes and 10′ deep.)

_____
_____
_____
_____
_____

Description of Liquid:

(Describe content of liquid including pollutants and expected temperature extremes in basin and at application point. Attach analysis of liquid chemistry, composition taken on a representative basis.)

Operational Characteristics:

(Describe the operation of the facility such as filling schedules, fluctuating liquid levels, operating temperatures, etc.)

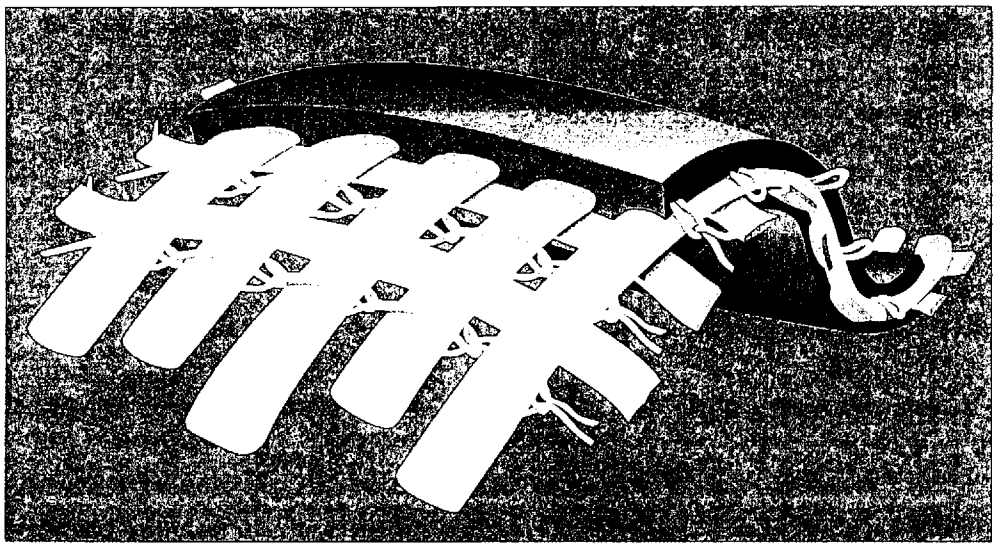
Performance Requirements, Etc:

(State any other requirements, such as rate of permeability required.)

Owner represents the information herein is complete and accurate, and understands and agrees that issuance of Seaman Corporation Warranty for XR products are conditioned upon such completeness and accuracy.

OWNER'S SIGNATURE

Reference Materials:



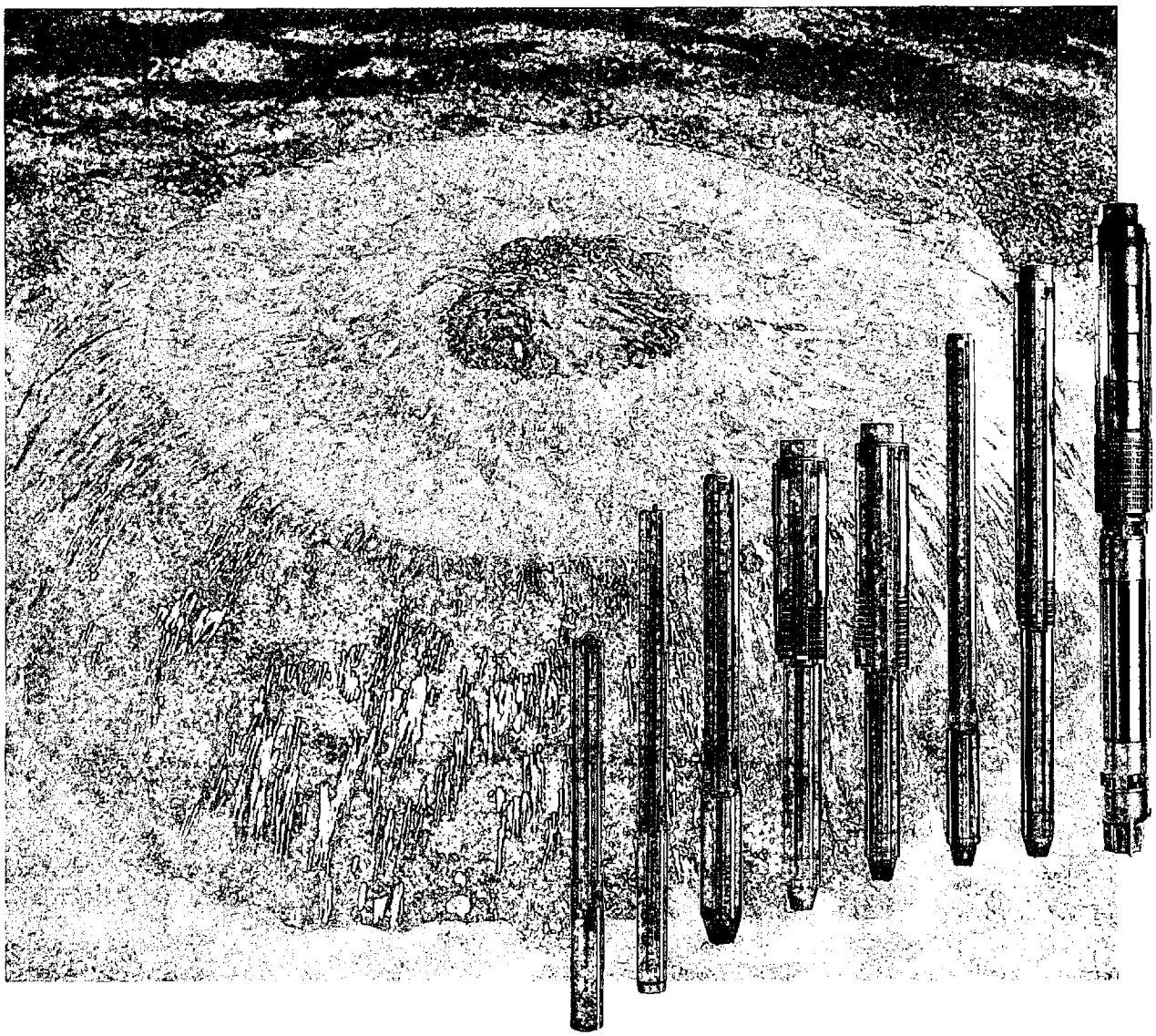
XR-5®: High Performance Composite Geomembrane

Seaman Corporation
1000 Venture Blvd.
Wooster, Ohio 44691
(330) 262-1111
www.xr-5.com

GRUNDFOS **PRODUCT GUIDE**

SP

Submersible pumps, motors, and accessories
60 Hz



BE > THINK > INNOVATE >

GRUNDFOS

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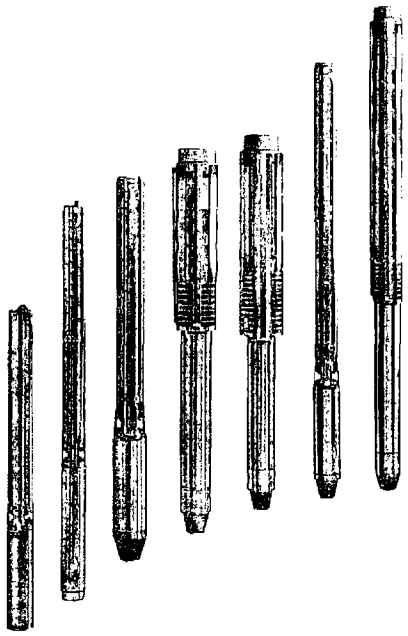
1. Product introduction

Introduction

The Grundfos SP range of submersible pumps is renowned for high efficiency and reliability. Made entirely of corrosion resistant stainless steel, SP pumps are ideal for a wide variety of applications.

Grundfos SP pumps represent state-of-the-art hydraulic design. Built to deliver optimum efficiency during periods of high demand, SP pumps provide low long-term costs and high operating reliability regardless of the application.

The SP range offers high efficiency, high resistance to sand and other abrasives, motor burnout protection, and easy maintenance. A complete monitoring and control system is available for constant optimization of the pumping system.



TM05 0051 0611

Fig. 1 Grundfos SP pumps

Applications

Grundfos Large SP submersible pumps are suitable for:

- Groundwater supply to waterworks
- Irrigation in horticulture and agriculture
- Groundwater lowering (dewatering)
- Pressure boosting
- Industrial applications
- Domestic water supply.

Pumped liquids

Grundfos SP pumps are suitable for pumping clean, thin, non-aggressive liquids without solid particles or fibers.

SP offers stainless steel construction which ensures good wear resistance and a reduced risk of corrosion where the water has minor chloride content.

Optional, upgraded stainless steel construction is available for pumping more aggressive liquids:

A complete range of zinc anodes for cathodic protection is available; see p. 97 for applications (for example, sea water applications).

For slightly polluted liquids (for example, containing oil), Grundfos offers a complete range of stainless steel SP NE pumps with all rubber parts made of FKM.

Features and benefits

Grundfos SP submersible pumps offer these features and benefits:

- State-of-the-art hydraulics provide high efficiency and low operating costs
- 100 % stainless steel components inside and outside for long service life
- Sand resistant
- Resistant to aggressive water
- Motor burnout protection via CU 301
- Dry-running protection
- Monitoring, protection and communication via protection unit MP204, and remote control, R100.

A wide pump range

Grundfos offers energy-efficient SP submersible pumps with a performance range of up to 1,400 gpm and 2,100 ft of head.

The pump range consists of many pump sizes, and each pump size is available with an optional number of stages to match any duty point.

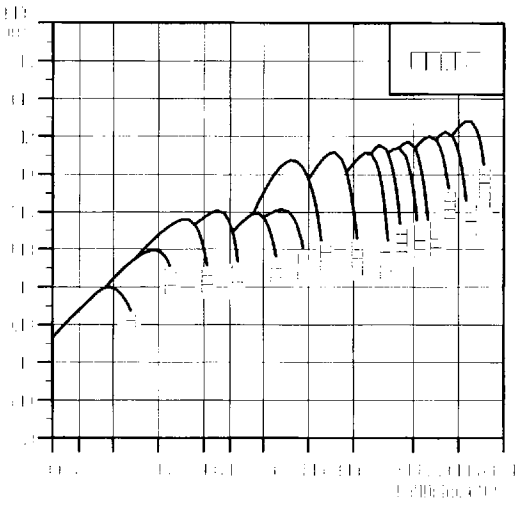
High pump efficiency

Often pump efficiency is given less consideration than the price of a pump; however, owners who choose efficiency will find substantial savings in energy costs over time. See fig. 2 for an illustration of SP efficiencies in relation to flow.

Example

For example, a pump and motor with a 10 % higher efficiency than a cheaper, less efficient pump, can save its owner more than $80,000.00 over 10 years*.

* If producing 880 gpm at 325 ft of head for 10 years @ 13.8 cents per kWh. U.S. kWh costs range from 6 cents to more than 20 cents, depending on region.



TM05 0057 0711

Fig. 2 SP pump/motor efficiencies in relation to flow

Pump design

Grundfos SP submersible pumps feature components that contribute to the superior performance and durability of the range.

Lower installation costs

Stainless steel means low weight for ease in the handling of pumps, resulting in lower equipment costs and reduced installation and service time.

Bearings with sand channels

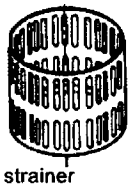
All bearings are water-lubricated and have a squared shape enabling sand particles, if any, to leave the pump together with the pumped liquid.

TM00 7301 1096

Fig. 3 Bearing

Inlet strainer

The inlet strainer prevents particles over a certain size from entering the pump.



TM00 7302 1096

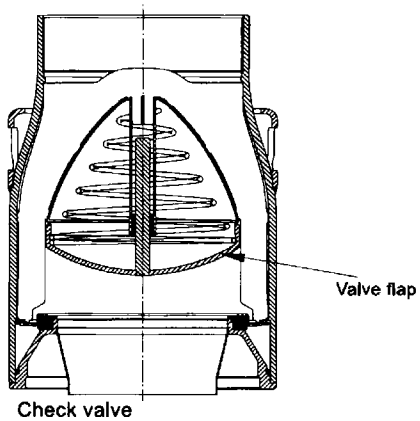
Fig. 4 Fig. Inlet strainer

Non-return valve

All pumps are equipped with a reliable check valve in the valve casing preventing back flow in connection with pump stoppage.

Furthermore, the short closing time of the check valve means that the risk of destructive water hammer is reduced to a minimum.

The valve casing is designed for optimum hydraulic properties to minimize the pressure loss across the valve and thus to contribute to the high efficiency of the pump.



TM01 2499 1798

Fig. 5 Check valve

Priming screw

All Grundfos 4" pumps are fitted with a priming screw. Consequently, dry running is prevented, because the priming screw will make sure that pump bearings are always lubricated.

Due to the semi-axial impellers of large SP pumps this priming is provided automatically.

However, it applies to all pump types that if the water table is lowered to a level below the pump inlet neither pump nor motor will be protected against dry running.

TM00 7304 1096

Fig. 6 Priming screw

Stop ring

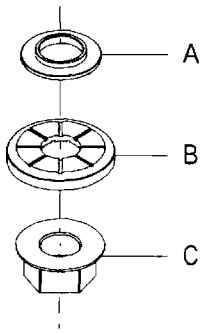
The stop ring prevents damage to the pump during transport and in case of up-thrust in connection with start-up.

The stop ring, which is designed as a thrust bearing, limits axial movements of the pump shaft.

Example: SP 385S

The stationary part of the stop ring (A) is secured in the upper intermediate chamber.

The rotating part (B) is fitted above the split cone (C).



TM01 3327 0412

Fig. 7 Stop ring (rotating and stationary part) and the split cone

Grundfos submersible motors

A complete motor range

Grundfos offers a complete submersible motor range in different voltages. For an overview of motor types, sizes and voltages, see page 85.

MS 402 is designed for the domestic ground water market and covers outputs. The MS 4000 and MS6 series are designed for use in a variety of applications in water supply. When equipped with features like oversized motor, temperature measurement, cooling jacket, and SiC/SiC mechanical shaft seals, these motors are suitable for heavy-duty industrial applications such as dewatering operations.

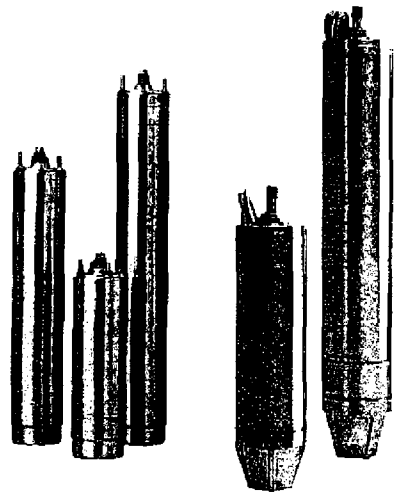
As a standard, all external surfaces of the Grundfos MS motors in contact with water are made of AISI 304 stainless steel. For aggressive water, such as seawater or brackish water, R-versions made of AISI 904 are available.

Grundfos rewindable MMS motor range

Grundfos MMS motors are suitable for any submersible installation, including heavy-duty industrial applications and dewatering operations (when equipped with temperature control, oversized motor, cooling jacket, and SiC/ SiC mechanical shaft seals).

As a standard the MMS motors are supplied with black cast-iron end-bells. Optionally, the range is available in all-stainless steel AISI 316 or AISI 904 versions.

The 2-pole Grundfos MMS submersible motors are all easy to rewind. The windings of the stator are made of a special water-proof wire of pure electrolytic copper sheathed with special non-hydroscopic thermoplastic material. The fine dielectric properties of this material allow direct contact between the windings and the liquid for efficient cooling of the windings.



TM00 7305 1096 - GrA4011 - GrA4013

Fig. 8 Grundfos MS motors

TM01 7873 4799

Fig. 9 Grundfos MMS motors

Industrial submersible motors and MS6 T60-versions

For heavy-duty applications Grundfos offers a complete motor range of industrial motors with up to 5 % higher efficiency than that of Grundfos' standard motors. The industrial motors are available in sizes as from 3 Hp up to 30 Hp.

The cooling of the motor is very efficient due to the large motor surface. The efficient cooling makes it possible to increase the liquid temperature to 140 °F (60 °C) at a minimum flow of 0.49 ft/s (0.15 m/s) past the motor.

The industrial motors are for customers who value low operating costs and long life higher than price.

Grundfos industrial motors are developed for difficult operating conditions. These motors will stand a higher thermal load than standard motors and thus have a longer life when subjected to high load. This applies whether the high load is caused by bad power supply, hot water, bad cooling conditions, high pump load etc.

Please note that heavy duty motors are longer than motors for standard conditions.

Overtemperature protection

Accessories for protection against overtemperature are available for both Grundfos MS and MMS submersible motors. When the temperature becomes too high, the protection device will cut out and damage to the pump and motor be avoided.

Restart of the motor after cut-out can be achieved in two ways:

- manual restart
- automatic restart.

Automatic restart means that the MP 204 attempts to restart the motor after 15 minutes. If the first attempt is not successful, restarting will be reattempted at 30-minute intervals.

MS

The Grundfos MS submersible motors (with the exception of MS 402) are available with a built-in Tempcon temperature transmitter for protection against overtemperature. By means of the transmitter, it is possible to read out and/or monitor the motor temperature via an MP 204 or a PR 5714 relay.

The Grundfos MS6 submersible motors can be fitted with a Pt100. The Pt100 is fitted in the motor and connected directly to the MP 204 or monitored by the PR 5714 relay.

MMS

For the protection of the Grundfos MMS submersible motors against overtemperature Grundfos offers the Pt100 temperature sensor as an optional extra.

The Pt100 is fitted in the motor and connected directly to the MP 204 or monitored by the PR 5714 relay.

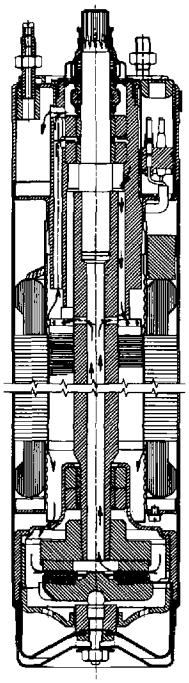
Protection against upthrust

In case of a very low counter pressure in connection with start-up there is a risk that the entire chamber stack may rise. This is called upthrust. Upthrust may damage both pump and motor. Both Grundfos pumps and motors are protected against upthrust as standard, preventing upthrust from occurring during the critical start-up phase. The protection consists of either a built-in stop ring or hydraulic balancing.

Built-in cooling chambers

In all Grundfos MS submersible motors, efficient cooling is ensured by cooling chambers at the top and at the bottom of the motor, and by an internal circulation of motor liquid.

See fig. 10. As long as the required flow velocity past the motor is maintained, cooling of the motor will be efficient.



TM00 5698 0996

Fig. 10 MS 4000

Lightning protection

The smallest Grundfos submersible motors, such as the MS 402, are all insulated in order to minimize the risk of motor burnout caused by lightning strike.

Reduced risk of short-circuit

The embedded stator winding in the Grundfos MS submersible motor is hermetically enclosed in stainless steel. The result is high mechanical stability and optimum cooling. Also, this eliminates the risk of short-circuit of the windings caused by water condensation.

Shaft seal

MS 402

The shaft seal is of the lip seal type characterized by low friction against the rotor shaft.

The rubber material offers good wear resistance, good elasticity and resistance to particles, and it is approved for use in drinking water.

MS 4000, MS6

The material is ceramic/tungsten carbide providing optimum sealing, optimum wear resistance and long life.

The spring loaded shaft seal is designed with a large surface and a sand shield. The result is a minimum exchange of pumped and motor liquids and no penetration of particles.

Motors, version R, are supplied with a SiC/SiC shaft seal. Other combinations are available request. See fig. 11 and fig. 12 for an illustration of shaft seal components and configuration.

MMS rewindable motors

The standard shaft seal is a ceramic/carbon mechanical shaft seal. The shaft seal is replaceable.

The material features good wear resistance and resistance to particles.

Together with the shaft seal housing, the sand shield forms a labyrinth seal, which during normal operating conditions prevents penetration of sand particles into the shaft seal.

On request, motors can be supplied with a SiC/SiC seal.

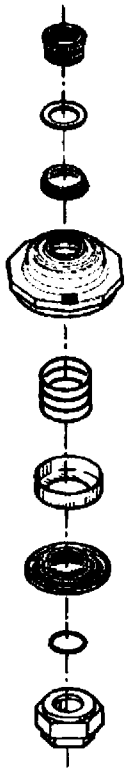


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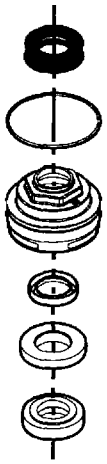
Fig. 11 Shaft seal, MS 4000



TM03 9225 3607

Fig. 12 Shaft seal, MS6

Identification

Type key, SP pumps

Example	475	S	500	-	5	-	A	B

- Rated flow rate in gpm
- Type range
  Stainless steel parts of material
  S= AISI 304
  N= AISI 316
  R= AISI 904L
- Hp of motor
- Number of impellers
- First reduced-diameter impeller (A, B or C)
- Second reduced-diameter impeller (A, B or C)

Type key, MS 4000 motors

Example	MS	4	000	R

- Motor submersible
- Min. borehole diameter in inches
- Generation
- - = Stainless steel AISI 304
  R = Stainless steel AISI 904L
  I = Stainless steel AISI 304 + De-rated
  RE = Stainless steel AISI 904 L + FKM
  EI = Stainless steel AISI 304 + De-rated + FKM

Type key, MS 402 motors

Example	MS	4	02

- Motor submersible
- Min. borehole diameter in inches
- Generation
- - = Stainless steel AISI 304

Type key, MMS motors

Example	MMS	6	000	N

- Type range
- Min. borehole diameter in inches
- Generation
- Material:
  = Cast iron EN-JL1040
  N = DIN/EN 1.4401 (AISI 316)

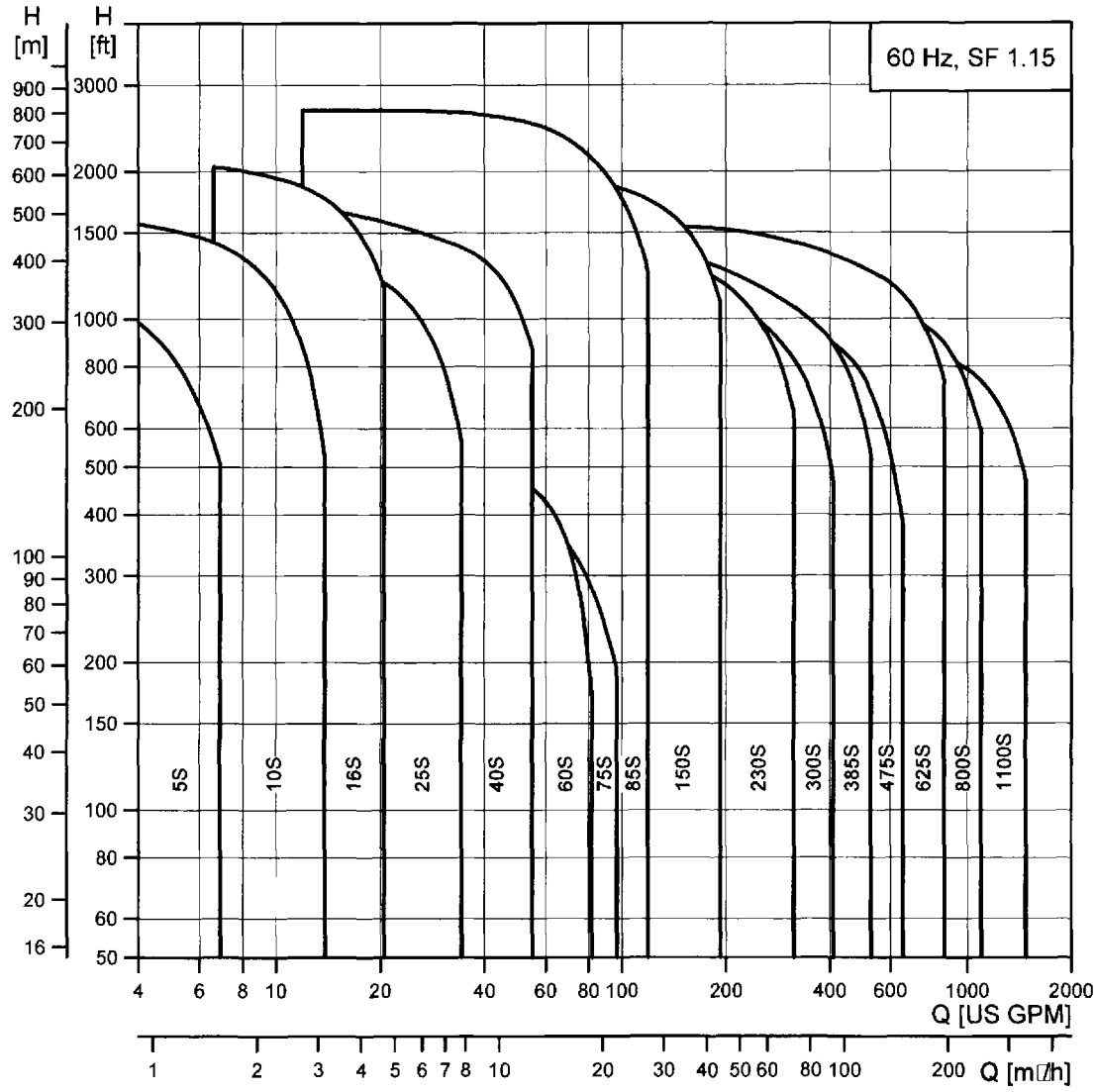
Type key, MS6 motors

Example	MS	6	R	E	S	W	D	T60

- Type range (Motor Submersible)
- **Motor diameter in inches**
- **Material**
  - Blank = stainless steel EN 1.4301 (AISI 304)
  - R = stainless steel EN 1.4539 (AISI 904L)
- **Rubber parts**
  - Blank = NBR
  - E = FKM
- **Shaft seal**
  - Blank = ceramics/carbon
  - S = SiC/SiC
- **Radial bearings**
  - Blank = carbon/stainless steel
  - W = SiC/tungsten carbide
- **Motor liquid**
  - Blank = SML-3
  - D = demineralized water
- **Maximum liquid temperature**
  - T30 = 86 °F (30 °C)
  - T60 = 140 °F (60 °C)

2. Product overview

Performance range 60 Hz



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Pump range

Type		5S	10S	16S	25S	40S	60S	75S	85S	150S	230S	300S	385S	475S	625S	800S	1100S
AISI 304 stainless steel		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
AISI 316 stainless steel				■	■	■		■	■	■	■	■	■	■	■	■	■
AISI 904L stainless steel					■	■			■	■	■	■	■	■	■	■	■
Connection ■	NPT	1"	1.25"	1.25"	1.5"	2"	2"	2"	(3")	(3")	3" (4")	3" 4"	5"	5"	6"	6"	6"
Flange connection: Grundfos flange													5"	5"	6"	6"	6"

■ Figures in brackets ( ) indicate connection for pumps with sleeve.

Motor range

Motor output [hp]	0.5	0.75	1.0	1.5	1.5	3.0	5.0	7.5	10.0	15	20	25	30	40	50	60	75	100	125	150	175	200	250
Single-phase	■	■	■	■	■	■																	
Three-phase	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Industrial motor and MS6 T60-versions						■	■	■	■	■	■	■	■										
Rewindable motor							■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Steel: AISI 304	■	■	■	■	■	■	■	■	■	■	■	■	■	■									
Steel: AISI 304 and cast iron							■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Steel: AISI 316							■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Steel: AISI 904L			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■			
Built-in temperature transmitter in motor			■	■	■	■	■	■	■	■	■	■	■	■									

Direct-on-line starting is recommended up to 100 hp.
Soft starter or autotransformer is recommended above 100 hp.
Motors with star/delta are available from 7.5 hp.

Motor protection and controllers

Motor output [hp]	0.5	0.75	1.0	1.5	1.5	3.0	5.0	7.5	10.0	15	20	25	30	40	50	60	75	100	125	150	175	200	250
MP 204	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Pt100							■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Zinc anode				■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Vertical flow sleeve	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Horizontal flow sleeve	■	■	■	■	■	■		■	■	■	■	■	■	■									
SA-SPM	■	■	■	■	■	■	■																
R100	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
RS-485 communication module	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
G100	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■

Motor protection of single-phase motors, see page 85.

3. Construction

Sectional drawing, SP pump, 4"

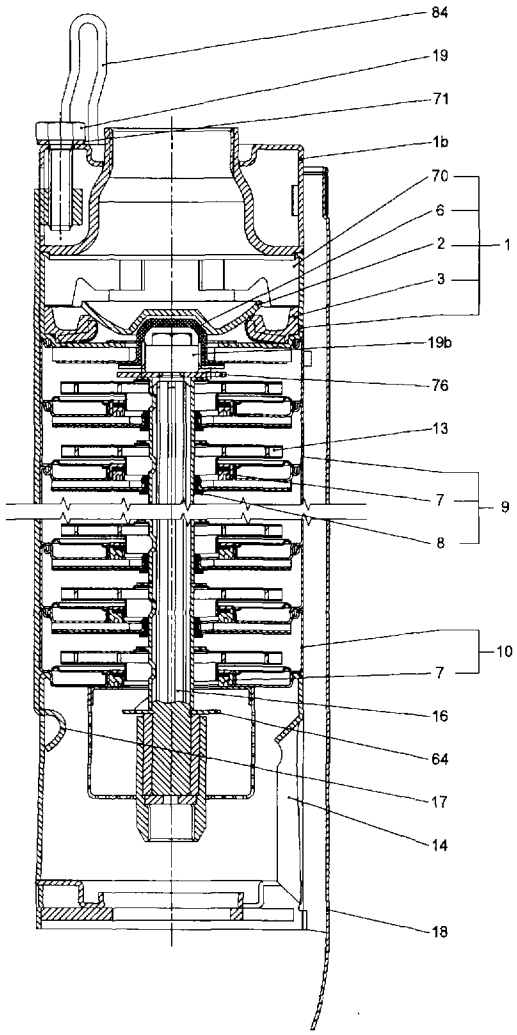
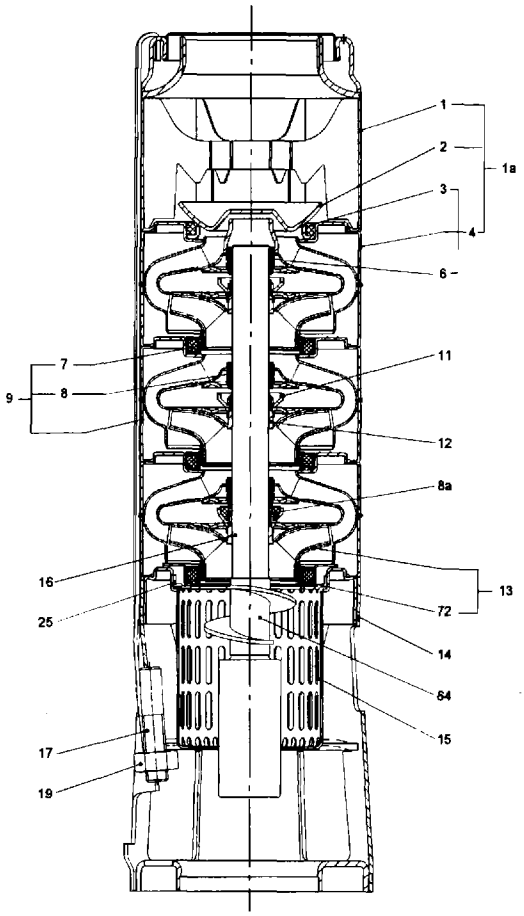


Fig. 13 SP pump, 4"

Material specification, SP pump, 4"

Pos.	Component	Materials	Standard AISI
1	Valve casing	Stainless steel	304
1b	Discharge piece	Stainless steel	304
2	Valve cup	Stainless steel	304
3	Valve seat	Stainless steel/NBR	304
6	Top bearing	NBR	
7	Neck ring	NBR/PBT	
8	Intermediate ring	NBR	
9	Intermediate chamber	Stainless steel	304
10	Bottom intermediate chamber	Stainless steel	304
13	Impeller	Stainless steel	304
14	Suction interconnector	Stainless steel	304
16	Shaft	Stainless steel	304
17	Strap	Stainless steel	304
18	Cable guard	Stainless steel	304
19	Hexagon screw	Stainless steel	304
19a	Nut	Stainless steel	316
19b	Nut	Stainless steel	304
20	Motor cable		
64	Priming disc	Stainless steel	304
70	Valve guide	Stainless steel	304
71	Washer for pos. 19	Stainless steel	316
76	Washer	Stainless steel	304
78	Nameplate	Stainless steel	316
84	Hook	Stainless steel	304

Sectional drawing, SP pump, 6"



TM01 2258 2602

Fig. 14 SP pump, 6"

Material specification, SP pump, 6"

Pos.	Component	Materials	Standard	N-version	R-version
			AISI		
		Valve casing			
1	Valve casing	Stainless steel	304	316	904 L
2	Valve cup	Stainless steel	304	316	904 L
3	Valve seat	Stainless steel	304	316	904 L
4	Top chamber	Stainless steel	304	316	904 L
		Chamber stack			
7	Neck ring	NBR/PPS			
8	Bearing	NBR			
8a	Spacing washer	Carbon/ graphite HY22 in PTFE mass			
9	Chamber	Stainless steel	304	316	904 L
11	Nut for split cone	Stainless steel	304	316	904 L
12	Split cone	Stainless steel	304	316	904 L
13	Impeller	Stainless steel	304	316	904 L
16	Shaft with coupling	Stainless steel	431	329	Si 31 803
18	Cable guard	Stainless steel	304	316	904 L
23	Rubber guard	NBR			
25	Neck ring retainer	Stainless steel	304	316	904 L
64	Priming screw	Stainless steel	304	316	904 L
72	Wear ring	Stainless steel	304	316	904 L
		Suction interconnector			
14	Suction interconnector	Stainless steel	304	316	904 L
	Intermediate piece for 6" motor over 40 Hp	Stainless steel	316	316	316
15	Strainer	Stainless steel	304	316	904 L
17	Strap	Stainless steel	304	316	904 L
19	Nut for strap	Stainless steel	304	316	904 L
19a	Nut	Stainless steel	316	316	316
20	Motor cable				
78	Nameplate	Stainless steel	316	316	316
		Pumps in sleeve			
	Clamping flange (counter)	Stainless steel	304	316	904 L
	Clamping flange	Stainless steel	304	316	904 L
	Connecting piece	Stainless steel	304	316	904 L
	Sleeve	Stainless steel	304	316	904 L
	Stay bolt	Stainless steel	304	316	904 L
	Hexagon socket head screw	Stainless steel	304	316	904 L

Sectional drawing, SP pump, 8"

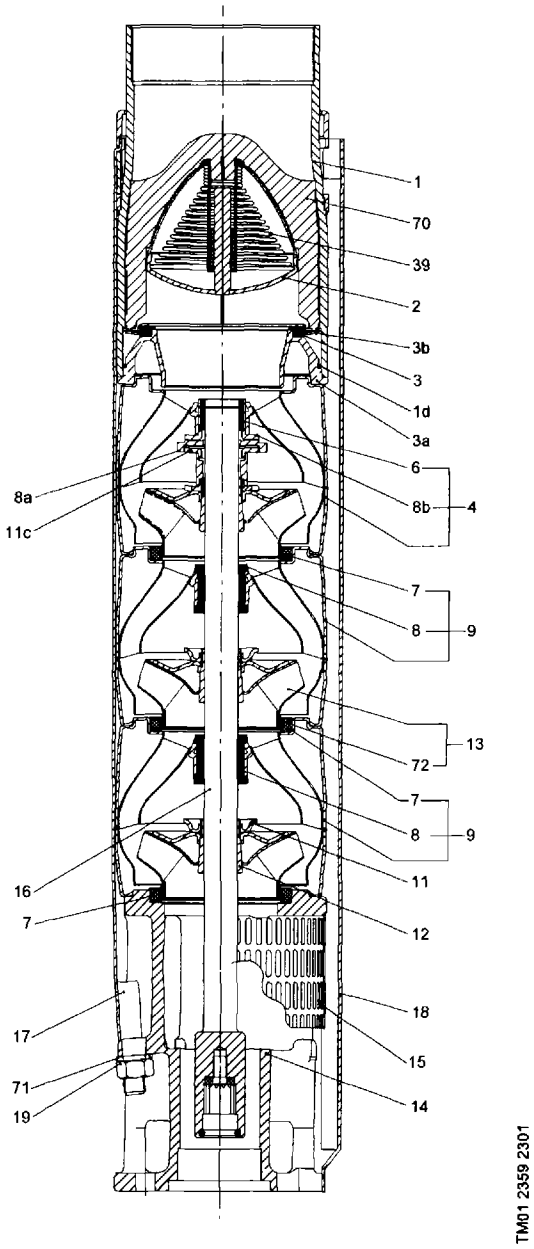
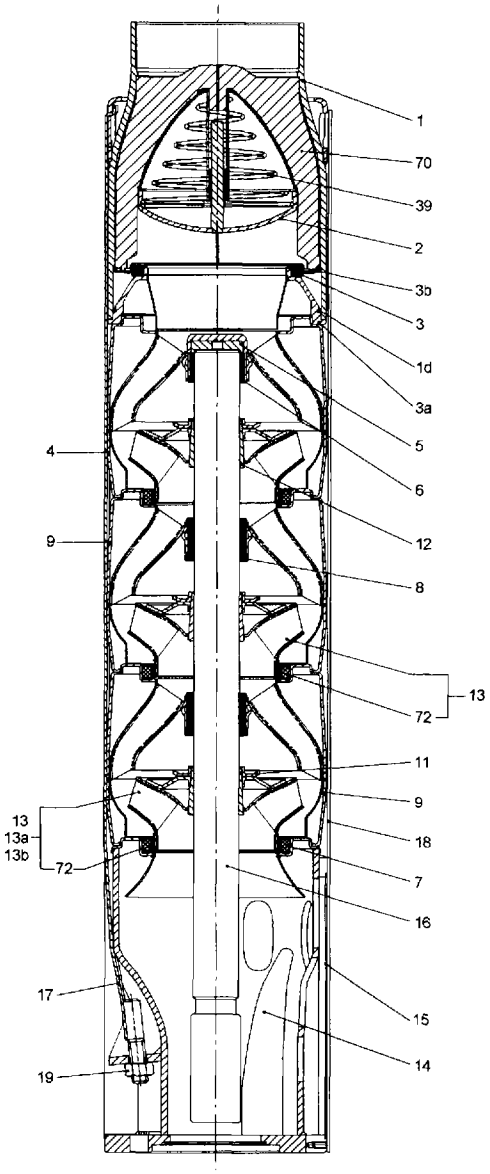


Fig. 15 SP pump, 8"

Material specification, SP pump, 8"

Pos.	Component	Materials	Standard	N-version	R-version
				AISI	
1	Valve casing	Stainless steel	304	316	904L
1d	O-ring	NBR			
2	Valve cup	Stainless steel	304	316	904L
3	Valve seat	Standard/ N- version: NBR R-version: FKM			
3a	Lower valve seat retainer	Stainless steel	316	316	(DIN 1.4517)
3b	Upper valve seat retainer	Stainless steel	304	316	904L
4	Top chamber	Stainless steel	304	316	904L
6	Upper bearing	Stainless steel/NBR	304	316	904L
7	Neck ring	NBR/PPS			
8	Bearing	NBR			
8a	Washer for stop ring	Carbon/ graphite HY22 in PTFE mass			
8b	Stop ring	Stainless steel	316	316	904L
9	Chamber	Stainless steel	304	316	904L
11	Split cone nut	Stainless steel	304	316	904L
11c	Nut for stop ring	Stainless steel	316	316	904L
12	Split cone	Stainless steel	304	316	904L
13	Impeller	Stainless steel	304	316	904L
14	Suction inter-connector	Stainless steel	CF8M	A744 CD4-MCu	(DIN 1.4517)
15	Strainer	Stainless steel	304	316	904L
16	Shaft complete	Stainless steel	431	329	329
17	Strap	Stainless steel	304	316	904L
18	Cable guard	Stainless steel	304	316	904L
19	Nut for strap	Stainless steel	304	316	904L
39	Spring for valve cup	Stainless steel	304	316	SAF 2205
70	Valve guide	Stainless steel	304	316	904L
71	Washer	Stainless steel	316	316	904L
72	Wear ring	Stainless steel	304	316	904L

Sectional drawing, SP pump, 10"



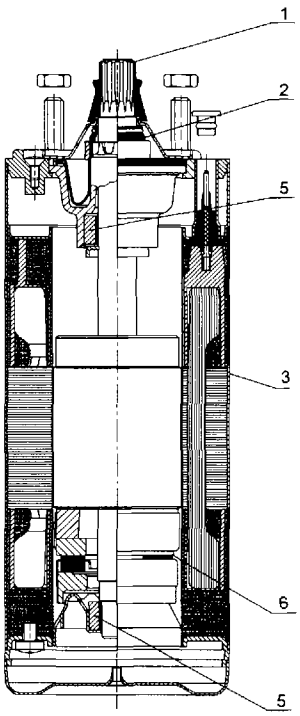
TM01 2363 2701

Fig. 16 SP pump, 10"

Material specification, SP pump, 10"

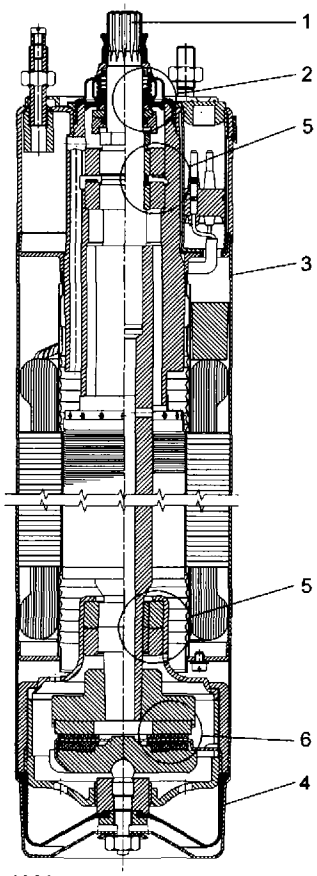
Pos.	Description	Material	Standard	N version
			AISI	
		Valve casing		
1	Valve casing	Stainless steel	304	316
1d	O-ring	NBR		
2	Valve cup	Stainless steel	304	316
3	Valve seat	Stainless steel	304	316
3a	Lower valve seat retainer	Stainless steel	304	316
3b	Upper valve seat retainer	Stainless steel	304	316
39	Spring for valve cup	Stainless steel	301	316
70	Valve guide	Stainless steel	304	316
78	Nameplate	Stainless steel	304	316
79	Rivet	Stainless steel	304	316
63	Connecting piece	Stainless steel	304	316
		Chamber stack		
4	Top chamber	Stainless steel	304	316
5	Upthrust disc	Carbon/ graphite HY22 in PTFE mass		
6	Top bearing	Stainless steel/ NBR	304	316
7	Neck ring	NBR/PPS		
8	Bearing	NBR		
9	Chamber	Stainless steel	304	316
11	Nut for split cone	Stainless steel	304	316
12	Split cone	Stainless steel	304	316
13	Impeller	Stainless steel	304	316
16	Shaft with coupling	Stainless steel	431	329
18	Cable guard	Stainless steel	304	316
18a, 18b	Screw for cable guard	Stainless steel	304	316
23	Rubber guard	NBR		
72	Wear ring	Stainless steel	304	316
		Suction interconnector		
14	Suction interconnector	Stainless steel	304	316
15	Strainer	Stainless steel	304	316
17	Strap	Stainless steel	304	316
19	Nut for strap	Stainless steel	304	316
19a	Nut	Stainless steel	316	316
20	Motor cable			
22	Bolts	Stainless steel	316	316
28, 28a	Lock for strainer	Stainless steel	329	329

Sectional drawing - MS motors



TM00 4736 0412

Fig. 17 MS 402 motor



TM00 7865 2196

Fig. 18 MS 4000 motor

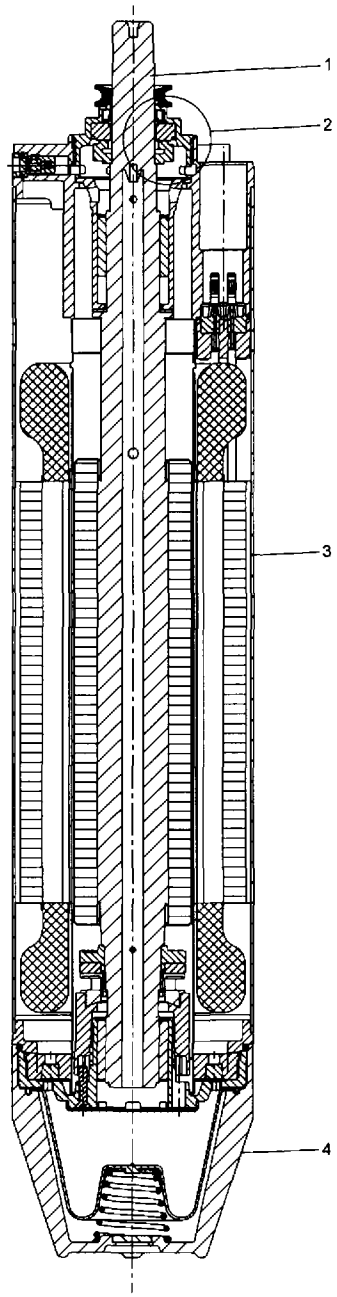
Material specification, MS 402 and MS 4000 motors

Pos.	Part	MS 402	MS 4000
		AISI	
1	Shaft	431	431
2	Shaft seal	NBR	Tungsten carbide/ ceramic
3	Motor sleeve	304	304
4	Motor end shield		304
5	Radial bearing	Ceramic	Ceramic/ tungsten carbide
6	Axial bearing	Ceramic/carbon	Ceramic/carbon
	Rubber parts	NBR	NBR

R-version motor

Pos.	Part	MS 4000
1	Shaft	318 LN
2	Shaft seal	NBR/ceramic
3	Motor sleeve	904L
4	Motor end shield	904L
5	Radial bearing	Ceramic/tungsten carbide
6	Thrust bearing	Ceramic/carbon
	Rubber parts	NBR

Sectional drawing - MS6 motors



TM03 9226 3607

Fig. 19 MS6 motor

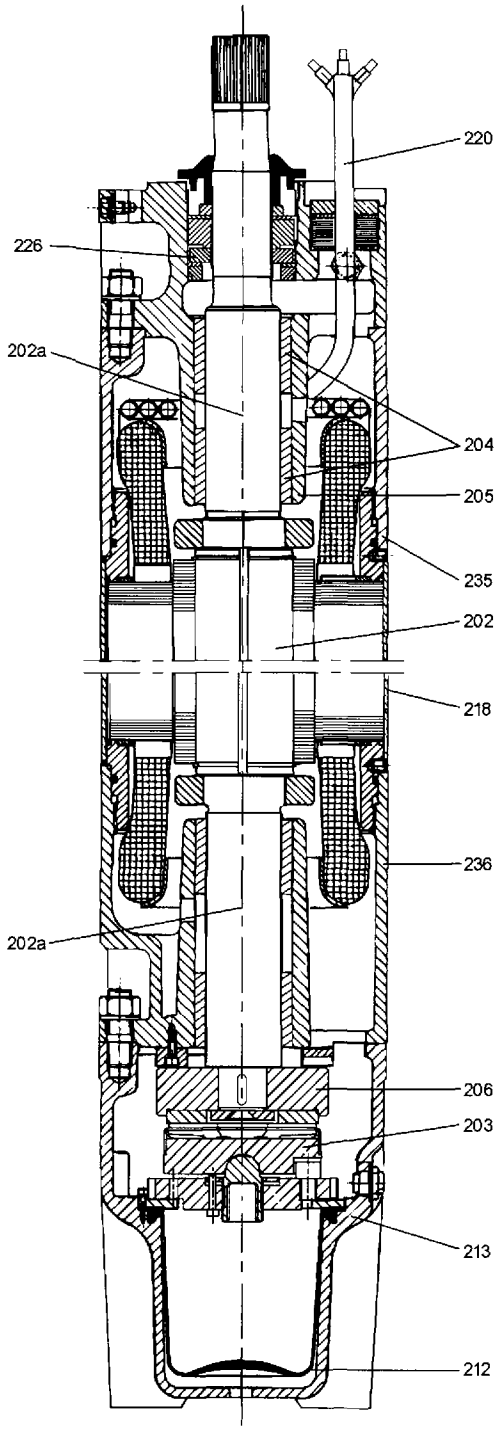
Material specification - MS6 motors

Pos.	Part	MS6
202	Shaft with rotor	318LN
2	Shaft seal	Ceramic/carbon
3	Motor sleeve	304
4	Motor end cover	304
	Rubber parts	NBR/FKM

R-version motor

Pos.	Part	MS6
1	Shaft	318LN
2	Shaft seal	SiC/SiC
3	Motor sleeve	904L
4	Motor end cover	(DIN 1.4517)
	Rubber parts	FKM

Sectional drawing - MMS motors



TM01 4985 0404

Fig. 20 MMS 10000

Material specification

MMS motors, submersible rewindable versions

Pos.	Component		Material	AISI
202	Shaft		Steel	(EN 1.0533)
202a	Shaft ends		Stainless steel	316/329
203/ 206	Thrust bearing Stationary/ rotating part	6", 0.5 - 20 Hp	Hardened steel/ EPDM	
		6", 25 - 50 Hp	Ceramic/ carbon	
		8" - 10"		
204	Bearing bush	6" - 10"	Carbon	
205	Bearing housing, upper		Cast iron	A126 Class B
212	Diaphragm		CR	
213	Motor end shield		Cast iron	A126 Class B
218	Motor sleeve		Stainless steel	304
220	Motor cable		EPDM	
226	Shaft seal		Ceramic/ carbon	
235	Intermediate housing		Cast iron	A126 Class B
236	Bearing housing, lower		Cast iron	A126 Class B

MMS motors, N- and R-versions

Pos.	Component		Material	Version N	Version R*
				AISI	
202	Shaft		Steel	(EN 1.0533)	(EN 1.0533)
202a	Shaft ends		Stainless steel	316/329	318LN
203/ 206	Thrust bearing Stationary/ rotating part	6", 0.5 - 20 Hp	Hardened steel/EPDM		
		6", 25 - 50 Hp	Ceramic/ carbon		
		8"-10"			
204	Bearing bush	6"-10"	Carbon		
205	Bearing housing, upper		Stainless steel	316	904L
212	Diaphragm		CR		
213	Motor end shield		Stainless steel	316	904L
218	Motor sleeve		Stainless steel	316	904L
220	Motor cable		EPDM		
226	Shaft seal		Ceramic/ carbon		
235	Intermediate housing		Stainless steel	316	904L
236	Bearing housing, lower		Stainless steel	316	904L

* Only MMS 6000 and MMS 8000 are available in R-versions

4. Operating conditions

Operating conditions

Flow rate, Q: 0.44 - 1475 gpm (0.1-335 m^3/h).

Head, H: Maximum 2657 ft (810 m).

Maximum liquid temperature

Motor	Installation		
	Flow velocity past motor	Vertical [°F (°C)]	Horizontal [°F (°C)]
Grundfos MS 4"and MS6 T30-versions	0.49 ft/s (0.15 m/s)	86 (30)	86 (30)
Grundfos 4" MS industry versions	0.49 ft/s (0.15 m/s)	140 (60)	140 (60)
Grundfos MS6 T60-versions	3.28 ft/s (1.0 m/s)	140 (60)	140 (60)
Grundfos MMS 6" to 12" rewindable with PVC in the windings	0.49 ft/s (0.15 m/s)	77 (25)	77 (25)
	1.64 ft/s (0.50 m/s)	86 (30)	86 (30)
Grundfos MMS 6" to 12" rewindable with PE/PA in the windings	0.49 ft/s (0.15 m/s)	104 (40)	104 (40)
	1.64 ft/s (0.50 m/s)	113 (45)	113 (45)

Note: Note: For MMS 6000, 0.5 hp; MMS 8000, 150 hp; the maximum liquid temperature is 9 °F (5 °C) lower than the values stated in the table. For MMS 10000, 250 hp, the temperature is 18 °F (10 °C) lower.

Operating pressure

Motor	Maximum operating pressure
Grundfos MS 4" and 6"	870 psi (6 Mpa) (60 bar)
Grundfos MMS 6" to 10" rewindable	

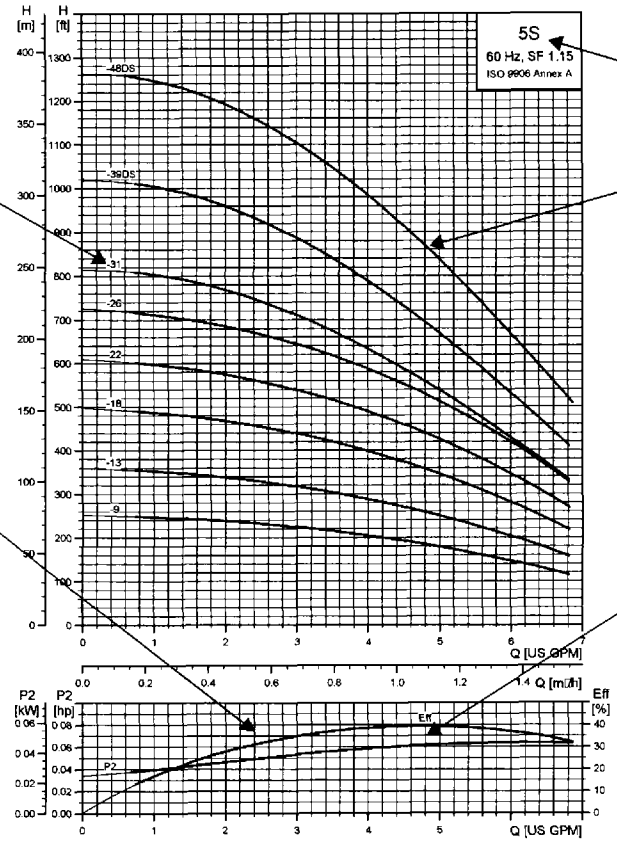
Curve conditions

The conditions below apply to the curves shown on pages 20 - 84:

General

- Curve tolerances according to ISO 9906, Annex A.
- The performance curves show pump performance at actual speed, cf. standard motor range.
  The speeds of the motors are approximately these:
  4" motors: n = 3470 min^{-1}
  6" motors: n = 3460 min^{-1}
  8" to 10" motors: n = 3525 min^{-1}
- The measurements were made with airless water at a temperature of 68 °F (20 °C). The curves apply to a kinematic viscosity of 1 mm^2/s (1 cSt). When pumping liquids with a density higher than that of water, use motors with correspondingly higher outputs.
- The **bold** curves indicate the recommended performance range.
- The performance curves are inclusive of possible losses such as non-return valve loss.
- **Q/H:** The curves are inclusive of valve and inlet losses at the actual speed.
  Operation without non-return valve will increase the actual head at rated performance by 0.5 to 1.0 m.
- **NPSH:** The curve is inclusive of pressure loss in the suction interconnector and shows required inlet pressure.
- **Power curve:** P_2 shows pump power input at the actual speed of each individual pump size.
- **Efficiency curve:** Eta shows pump stage efficiency. If Eta for the actual pump size is needed, please consult WinCAPS or WebCAPS.

5. How to read the curve charts



Pump type, number of poles and frequency.

Number of stages.
First figure: number of stages; second figure: number of reduced-diameter impellers.

QH curve for the individual pump. The **bold** curves indicate the **recommended** performance range for best efficiency.

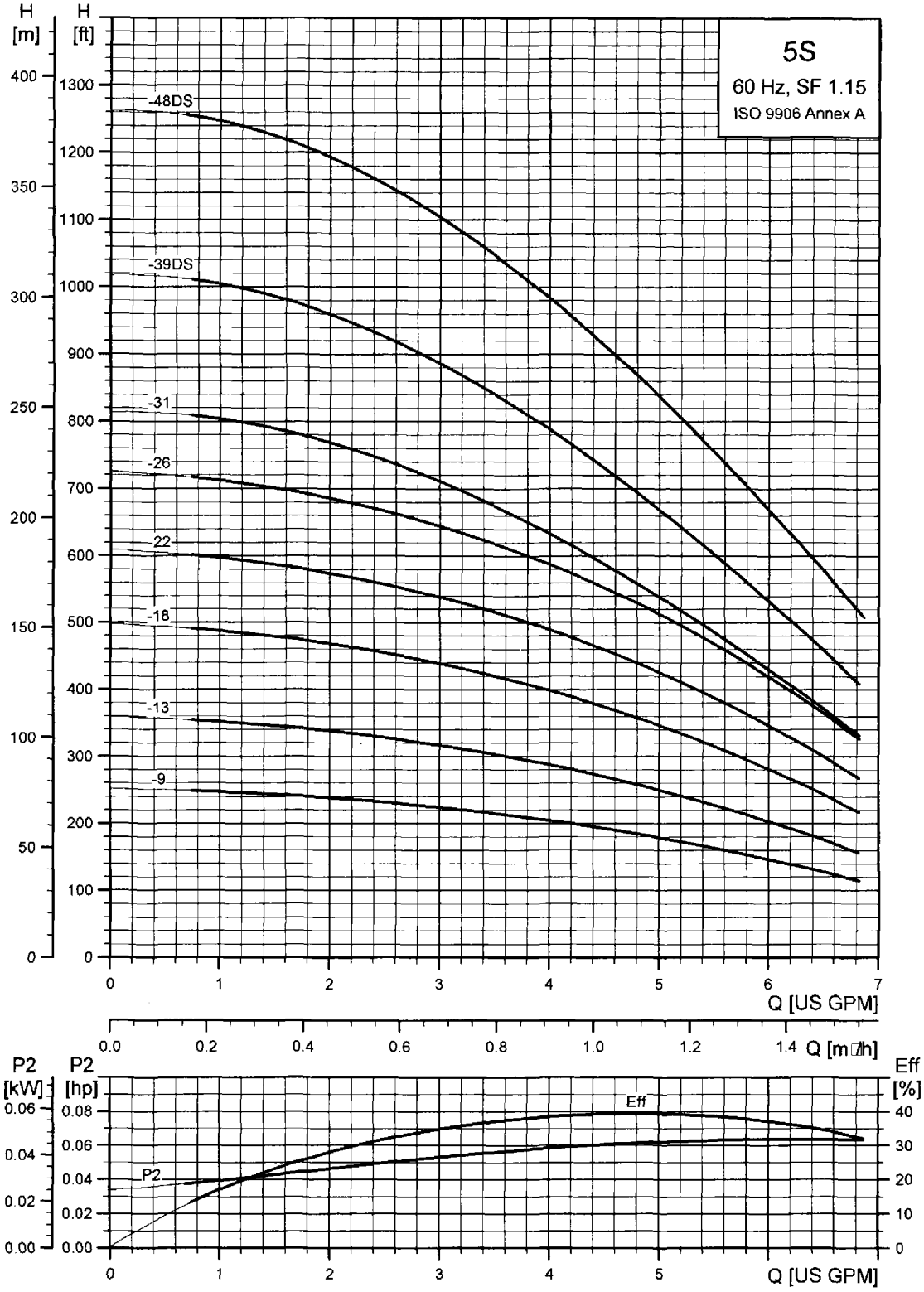
The efficiency curve shows the efficiency of the pump. The efficiency curve is an average curve of all the pump types shown in the chart. The efficiency of pumps with reduced-diameter impellers is approx. 2 % lower than the efficiency curve shown in the chart.

The power curves indicate pump input power **per stage**. Curves are shown for complete (1/1) and for reduced-diameter (2/3) impellers.

TM05 0229 10112

6. Curve charts and technical data

5S (5 gpm)



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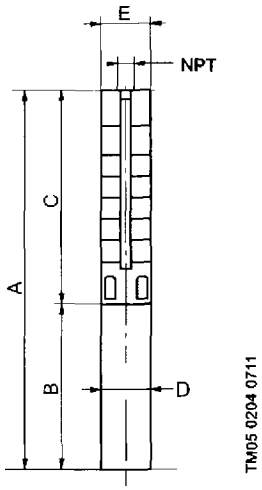
5S (5 gpm)

Pump model	Nom. head [ft]	Ph	Volts [V]	Motor [Hp]		Dimensions A [in (mm)]	B [in (mm)]	C [in (mm)]	D [in (mm)]	E [in (mm)]	Net weight (complete) [lb]
5S, motor dia. 4 inch, 2 wire motor, 60 Hz - rated flow 5 gpm (1" NPT)											
5S05-9	171	1	230	0.5	■	24.57 (624)	11.03 (280)	13.55 (344)	3.74 (95)	3.97 (101)	21.6
5S05-13	247	1	115	0.5	■	27.88 (708)	11.03 (280)	16.86 (428)	3.74 (95)	3.97 (101)	26.9
			230	0.5	■	27.88 (708)	11.03 (280)	16.86 (428)	3.74 (95)	3.97 (101)	26.1
5S07-18	343	1	230	0.75	■	32.60 (828)	11.62 (295)	20.99 (533)	3.74 (95)	3.97 (101)	29.7
5S10-22	419	1	230	1	■	36.50 (927)	12.21 (310)	24.30 (617)	3.74 (95)	3.97 (101)	32.4
5S15-26	495	1	230	1.5	■	41.30 (1049)	13.71 (348)	27.60 (701)	3.74 (95)	3.97 (101)	41.4
5S15-31	527	1	230	1.5	■	47.21 (1199)	13.71 (348)	33.51 (851)	3.74 (95)	3.97 (101)	47.7
5S, motor dia. 4 inch, 3 wire motor, 60 Hz - rated flow 5 gpm (1" NPT)											
5S05-9	171	1	230	0.5	■	24.57 (624)	11.03 (280)	13.55 (344)	3.74 (95)	3.97 (101)	22.5
5S05-13	247	1	115	0.5	■	27.88 (708)	11.03 (280)	16.86 (428)	3.74 (95)	3.97 (101)	26.9
			230	0.5	■	27.88 (708)	11.03 (280)	16.86 (428)	3.74 (95)	3.97 (101)	25.2
5S07-18	343	1	230	0.75	■	32.60 (828)	11.62 (295)	20.99 (533)	3.74 (95)	3.97 (101)	28.8
5S10-22	419	1	230	1	■	36.50 (927)	12.21 (310)	24.30 (617)	3.74 (95)	3.97 (101)	32.4
5S15-26	495	1	230	1.5	■	41.30 (1049)	13.71 (348)	27.60 (701)	3.74 (95)	3.97 (101)	37.8
		3	230	1.5	■	39.81 (1011)	12.21 (310)	27.60 (701)	3.74 (95)	3.97 (101)	38.7
			460	1.5	■	39.81 (1011)	12.21 (310)	27.60 (701)	3.74 (95)	3.97 (101)	38.7
5S15-31	527	1	230	1.5	■	47.21 (1199)	13.71 (348)	33.51 (851)	3.74 (95)	3.97 (101)	47.7
		3	230	1.5	■	45.71 (1161)	12.21 (310)	33.51 (851)	3.74 (95)	3.97 (101)	45.0
			460	1.5	■	45.71 (1161)	12.21 (310)	33.51 (851)	3.74 (95)	3.97 (101)	45.0
5S20-39DS	663	1	230	2	♦	59.61 (1514)	19.49 (495)	40.12 (1019)	3.74 (95)	3.97 (101)	57.6
		3	230	2	■	53.82 (1367)	13.71 (348)	40.12 (1019)	3.74 (95)	3.97 (101)	54.0
			460	2	■	53.82 (1367)	13.71 (348)	40.12 (1019)	3.74 (95)	3.97 (101)	54.0
5S30-48DS	816	1	230	3	•	70.16 (1782)	22.60 (574)	47.56 (1208)	3.74 (95)	3.97 (101)	77.4
		3	230	3	•	65.56 (1665)	18.00 (457)	47.56 (1208)	3.74 (95)	3.97 (101)	77.4
			460	3	•	65.56 (1665)	18.00 (457)	47.56 (1208)	3.74 (95)	3.97 (101)	77.4

5S

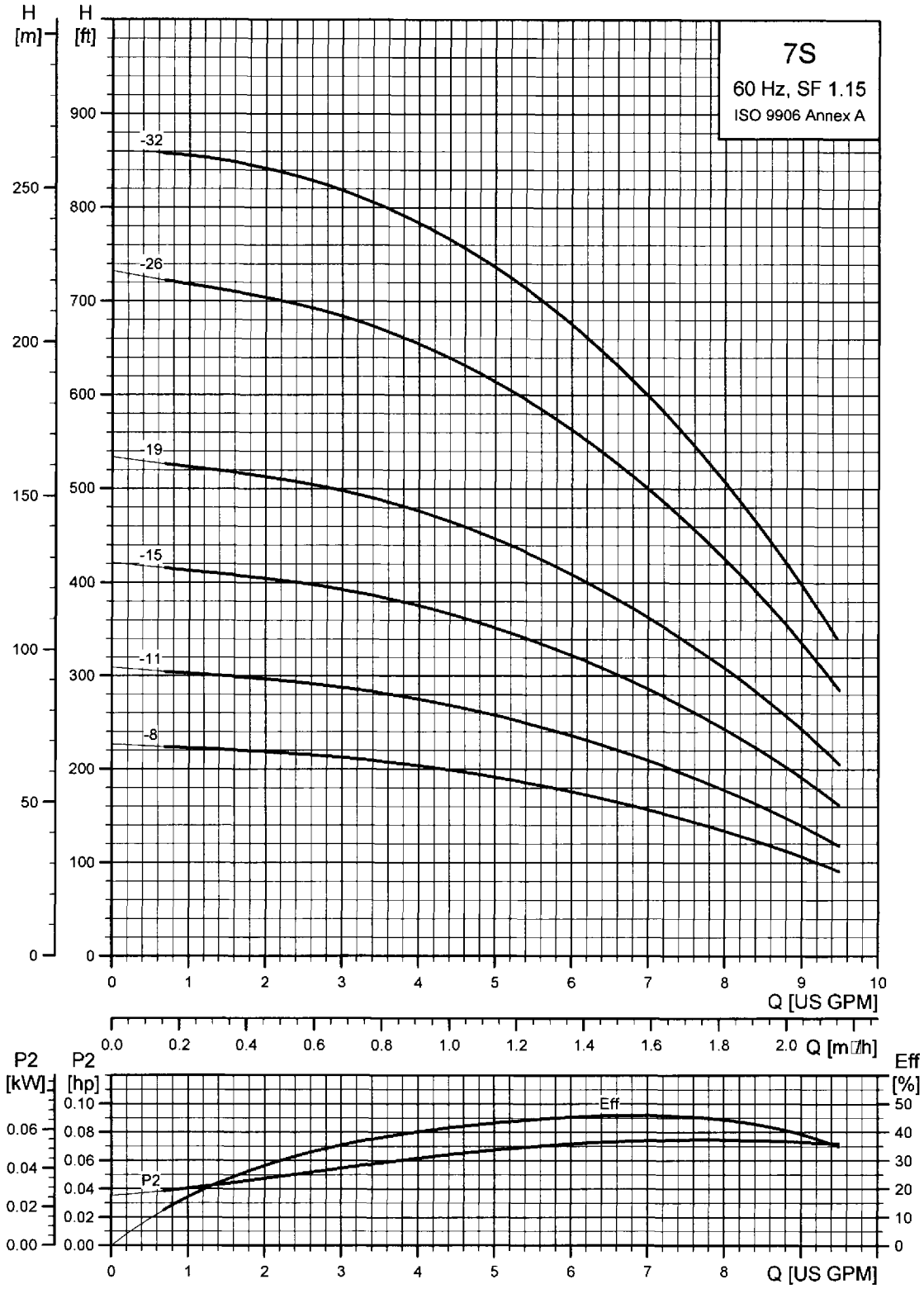


E = Maximum diameter of pump including cable guard and motor.

Notes:
Control box is required for 3-wire, single-phase applications. Data does not include control box.
DS designation = Built into sleeve, 1-1/4" NPT, 6" minimum well diameter.

■ MS402 motor.
• MS4000 motor.
▲ MS6 motor.
∧ MMS6000 motor.
★ MMS8000 motor.
♦ Takes MS6 motor; not available as complete.
☼ Takes MMS6000 motor; not available as complete.
* Takes MMS8000 motor; not available as complete.
† Takes MMS10000 motor; not available as complete.

7S (7 gpm)



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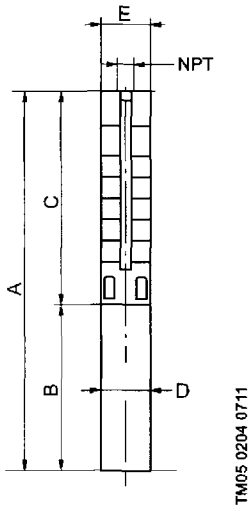
7S (7 gpm)

Pump model	Nom. head [ft]	Ph	Volts [V]	Motor [Hp]		Dimensions A [in (mm)]	B [in (mm)]	C [in (mm)]	D [in (mm)]	E [in (mm)]	Net weight (complete) [lb]
7S, motor dia. 4 inch, 2 wire motor, 60 Hz - rated flow 7 gpm (1" NPT)											
7S05-8	151	1	230	.5	■	23.75 (603)	11.03 (280)	12.72 (323)	3.74 (95)	3.97 (101)	21.6
7S05-11	208	1	115	.5	■	26.23 (666)	11.03 (280)	15.20 (386)	3.74 (95)	3.97 (101)	29.7
			230	.5	■	26.23 (666)	11.03 (280)	15.20 (386)	3.74 (95)	3.97 (101)	24.3
7S07-15	283	1	230	.75	■	30.12 (765)	11.62 (295)	18.51 (470)	3.74 (95)	3.97 (101)	29.7
7S10-19	358	1	230	1	■	34.02 (864)	12.21 (310)	21.82 (554)	3.74 (95)	3.97 (101)	32.4
7S15-26	491	1	230	1.5	■	41.3 (1049)	13.71 (348)	27.60 (701)	3.74 (95)	3.97 (101)	41.4
7S, motor dia. 4 inch, 3 wire motor, 60 Hz - rated flow 7 gpm (1" NPT)											
7S05-8	151	1	230	.5	■	23.75 (603)	11.03 (280)	12.72 (323)	3.74 (95)	3.97 (101)	21.6
7S05-11	208	1	115	.5	■	26.23 (666)	11.03 (280)	15.20 (386)	3.74 (95)	3.97 (101)	21.6
			230	.5	■	26.23 (666)	11.03 (280)	15.20 (386)	3.74 (95)	3.97 (101)	30.6
7S07-15	283	1	230	.75	■	30.12 (765)	11.62 (295)	18.51 (470)	3.74 (95)	3.97 (101)	27.9
7S10-19	358	1	230	1	■	34.02 (864)	12.21 (310)	21.82 (554)	3.74 (95)	3.97 (101)	39.6
7S15-26	491	1	230	1.5	■	41.30 (1049)	13.71 (348)	27.60 (701)	3.74 (95)	3.97 (101)	38.7
		3	230	1.5	■	39.81 (1011)	12.21 (310)	27.60 (701)	3.74 (95)	3.97 (101)	38.7
			460	1.5	■	39.81 (1011)	12.21 (310)	27.60 (701)	3.74 (95)	3.97 (101)	38.7
7S20-32	604	1	230	2	•	52.05 (1322)	19.49 (495)	32.56 (827)	3.74 (95)	3.97 (101)	48.5
		3	230	2	■	46.26 (1175)	13.71 (348)	32.56 (827)	3.74 (95)	3.97 (101)	48.5
			460	2	■	46.26 (1175)	13.71 (348)	32.56 (827)	3.74 (95)	3.97 (101)	48.5

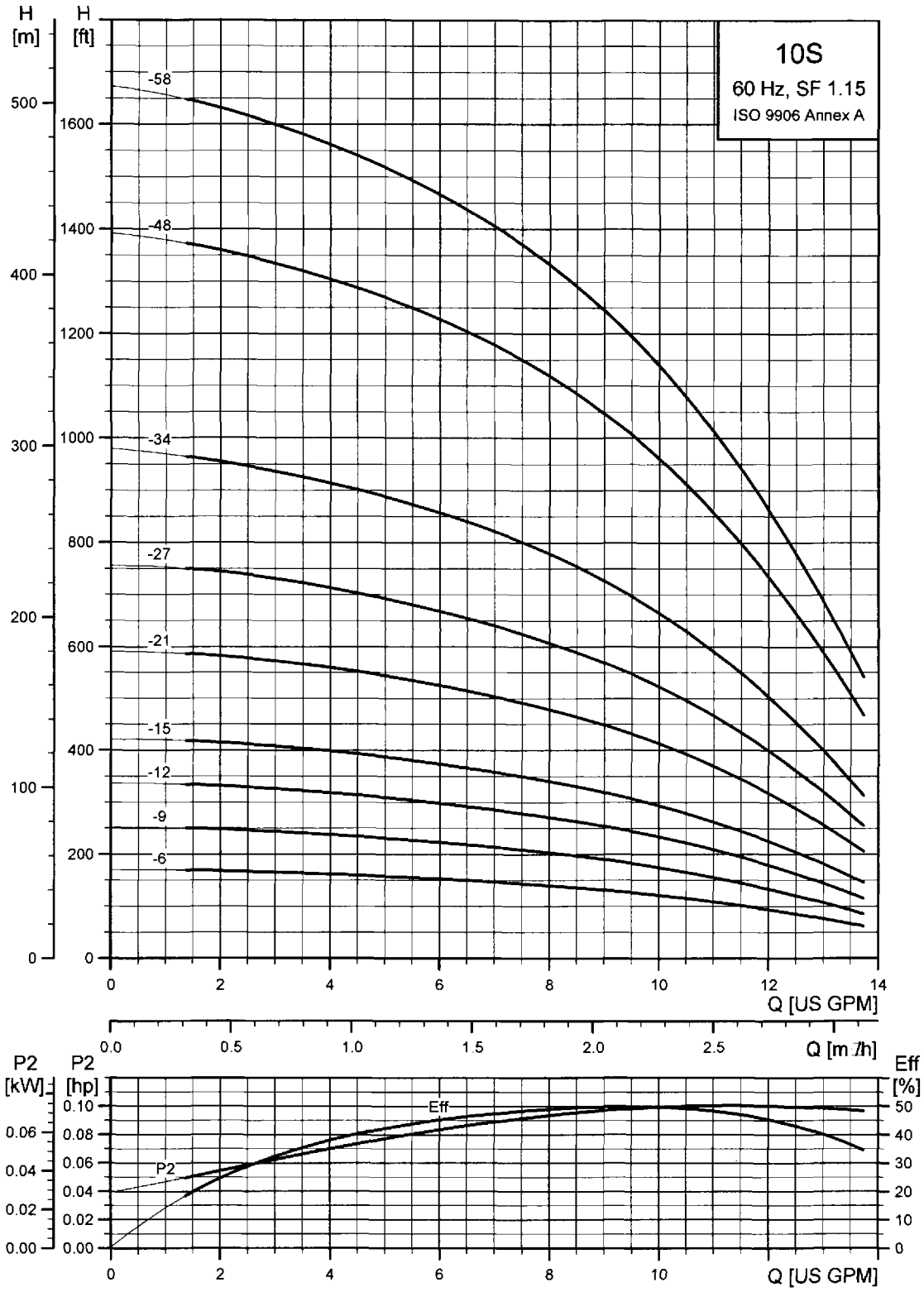
7S



E = Maximum diameter of pump including cable guard and motor.

Notes:
Control box is required for 3-wire, single-phase applications. Data does not include control box.
■ MS402 motor.
• MS4000 motor.
▲ MS6 motor.
∧ MMS6000 motor.
★ MMS8000 motor.
♦ Takes MS6 motor; not available as complete.
☼ Takes MMS6000 motor; not available as complete.
* Takes MMS8000 motor; not available as complete.
† Takes MMS10000 motor; not available as complete.

10S (10 gpm)



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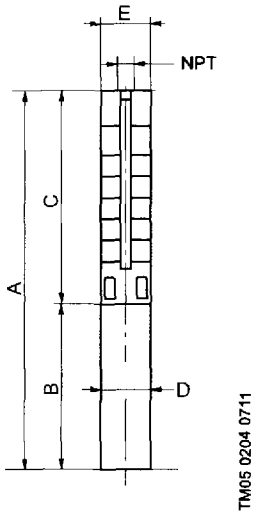
10S (10 gpm)

Pump model	Nom. head [ft]	Ph	Volts [V]	Motor [Hp]		Dimensions A [in (mm)]	B [in (mm)]	C [in (mm)]	D [in (mm)]	E [in (mm)]	Net weight (complete) [lb]
10S, motor dia. 4 inch, 2 wire motor, 60 Hz - rated flow 10 gpm (1.25" NPT)											
10S05-6	116	1	230	.5	■	22.05 (560)	10.99 (279)	11.07 (281)	3.74 (95)	3.97 (101)	20.7
10S05-9	174	1	115	.5	■	24.53 (623)	10.99 (279)	13.55 (344)	3.74 (95)	3.97 (101)	24.3
			230	.5	■	24.53 (623)	10.99 (279)	13.55 (344)	3.74 (95)	3.97 (101)	23.4
10S07-12	233	1	230	.75	■	27.60 (701)	11.58 (294)	16.03 (407)	3.74 (95)	3.97 (101)	24.3
10S10-15	291	1	230	1	■	30.67 (779)	12.17 (309)	18.51 (470)	3.74 (95)	3.97 (101)	29.7
10S15-21	407	1	230	1.5	■	37.17 (944)	13.71 (348)	23.47 (596)	3.74 (95)	3.97 (101)	35.1
10S, motor dia. 4 inch, 3 wire motor, 60 Hz - rated flow 10 gpm (1.25" NPT)											
10S05-6	116	1	230	.5	■	24.77 (629)	13.71 (348)	11.07 (281)	3.74 (95)	3.97 (101)	21.6
10S05-9	174	1	115	.5	■	24.53 (623)	10.99 (279)	13.55 (344)	3.74 (95)	3.97 (101)	25.4
			230	.5	■	24.53 (623)	10.99 (279)	13.55 (344)	3.74 (95)	3.97 (101)	24.3
10S07-12	233	1	230	.75	■	27.60 (701)	11.58 (294)	16.03 (407)	3.74 (95)	3.97 (101)	28.8
10S10-15	291	1	230	1	■	30.67 (779)	12.17 (309)	18.51 (470)	3.74 (95)	3.97 (101)	29.7
10S15-21	407	1	230	1.5	■	37.17 (944)	13.71 (348)	23.47 (596)	3.74 (95)	3.97 (101)	35.1
		3	230	1.5	■	35.63 (905)	12.17 (309)	23.47 (596)	3.74 (95)	3.97 (101)	32.4
			460	1.5	■	35.63 (905)	12.17 (309)	23.47 (596)	3.74 (95)	3.97 (101)	36.0
10S20-27	524	1	230	2	•	47.92 (1217)	19.49 (495)	28.43 (722)	3.74 (95)	3.97 (101)	45.9
		3	230	2	■	42.13 (1070)	13.71 (348)	28.43 (722)	3.74 (95)	3.97 (101)	44.1
			460	2	■	42.13 (1070)	13.71 (348)	28.43 (722)	3.74 (95)	3.97 (101)	44.1
10S30-34	659	1	230	3	•	58.59 (1488)	22.6 (574)	35.99 (914)	3.74 (95)	3.97 (101)	81.9
		3	230	3	•	53.98 (1371)	18.00 (457)	35.99 (914)	3.74 (95)	3.97 (101)	74.7
			460	3	•	53.98 (1371)	18.00 (457)	35.99 (914)	3.74 (95)	3.97 (101)	74.7
10S50-48DS	931	1	230	5	•	74.18 (1884)	26.62 (676)	47.56 (1208)	3.74 (95)	3.97 (101)	103.5
		3	230	5	•	70.16 (1782)	22.60 (574)	47.56 (1208)	3.74 (95)	3.97 (101)	103.5
			460	5	•	70.16 (1782)	22.60 (574)	47.56 (1208)	3.74 (95)	3.97 (101)	103.5
10S50-58DS	1124	1	230	5	•	89.49 (2272)	26.62 (676)	62.88 (1597)	3.74 (95)	4.25 (108)	132.3
		3	230	5	•	85.48 (2171)	22.60 (574)	62.88 (1597)	3.74 (95)	4.25 (108)	132.3
			460	5	•	85.48 (2171)	22.60 (574)	62.88 (1597)	3.74 (95)	4.25 (108)	132.3

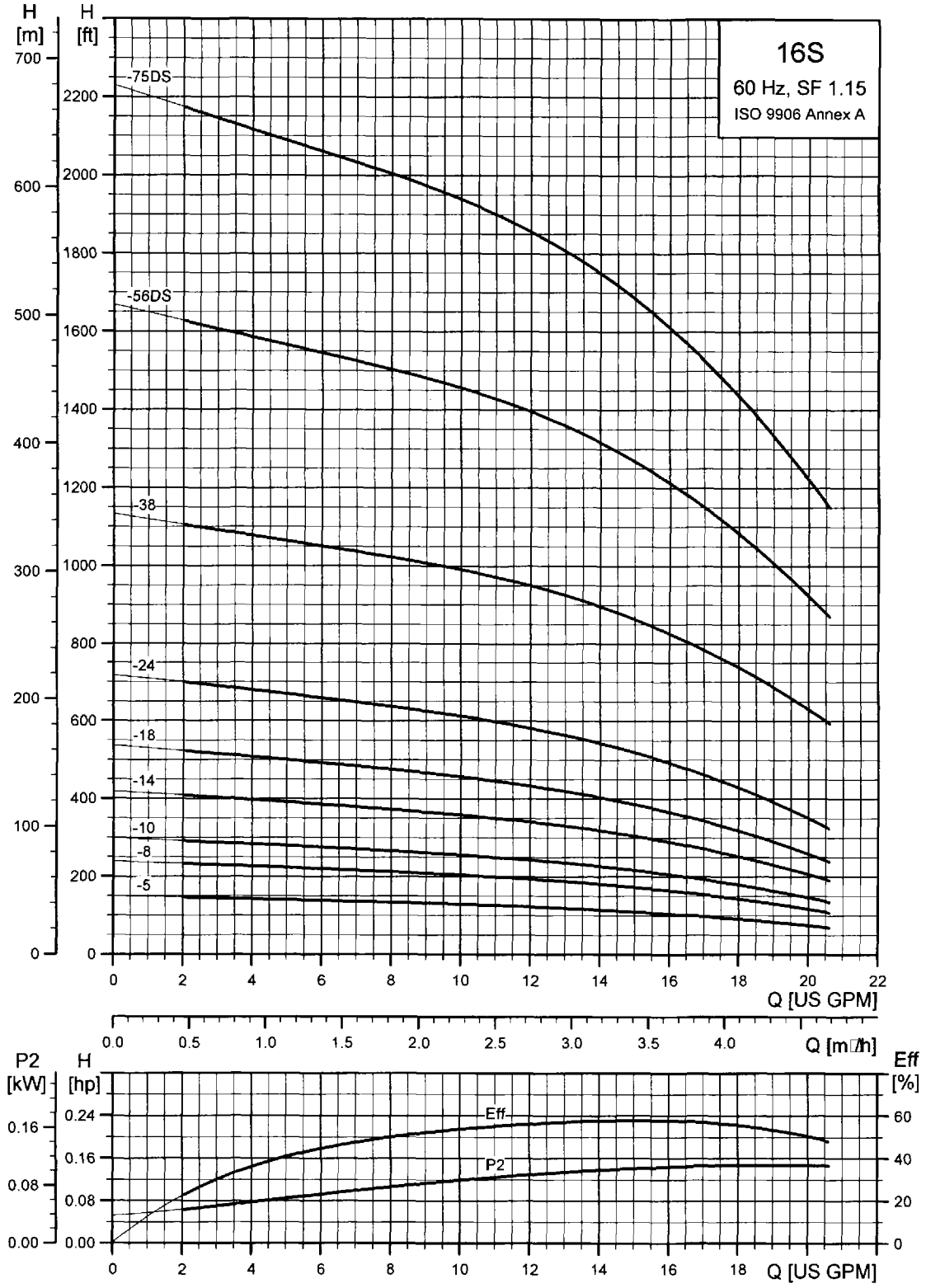
Notes:
Control box is required for 3-wire, single-phase applications. Data does not include control box.
DS designation = Built into sleeve, 1-1/4" NPT, 6" minimum well diameter.
■ MS402 motor.
• MS4000 motor.
▲ MS6 motor.
∧ MMS6000 motor.
★ MMS8000 motor.
♦ Takes MS6 motor; not available as complete.
☼ Takes MMS6000 motor; not available as complete.
* Takes MMS8000 motor; not available as complete.
† Takes MMS10000 motor; not available as complete.

10S



E = Maximum diameter of pump including cable guard and motor.

16S (16 gpm)



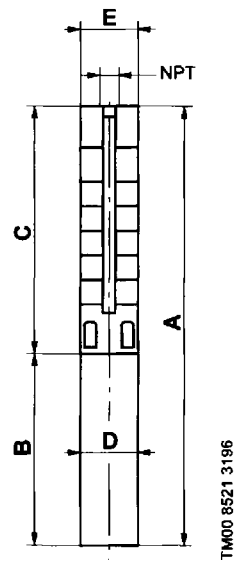
TM05 0231 0112

16S (16 gpm)

Pump model	Nom. head [ft]	Ph	Volts [V]	Motor [Hp]		Dimensions A [in (mm)]	B [in (mm)]	C [in (mm)]	D [in (mm)]	E [in (mm)]	Net weight (complete) [lb]
16S, motor dia. 4 inch, 2 wire motor, 60 Hz - rated flow 16 gpm (1.25" NPT)											
16S05-5	102	1	115	.5	■	21.26 (540)	11.03 (280)	10.24 (260)	3.74 (95)	3.97 (101)	21.6
			230	.5	■	21.26 (540)	11.03 (280)	10.24 (260)	3.74 (95)	3.97 (101)	23.4
16S07-8	162	1	230	.75	■	24.34 (618)	11.62 (295)	12.72 (323)	3.74 (95)	3.97 (101)	24.3
16S10-10	203	1	230	1	■	26.58 (675)	12.21 (310)	14.38 (365)	3.74 (95)	3.97 (101)	27.9
16S15-14	284	1	230	1.5	■	31.38 (797)	13.71 (348)	17.68 (449)	3.74 (95)	3.97 (101)	36.0
16S, motor dia. 4 inch, 3 wire motor, 60 Hz - rated flow 16 gpm (1.25" NPT)											
16S05-5	102	1	115	.5	■	21.26 (540)	11.03 (280)	10.24 (260)	3.74 (95)	3.97 (101)	21.6
			230	.5	■	21.26 (540)	11.03 (280)	10.24 (260)	3.74 (95)	3.97 (101)	21.6
16S07-8	162	1	230	.75	■	24.34 (618)	11.62 (295)	12.72 (323)	3.74 (95)	3.97 (101)	27.0
16S10-10	203	1	230	1	■	26.58 (675)	12.21 (310)	14.38 (365)	3.74 (95)	3.97 (101)	27.9
16S15-14	284	1	230	1.5	•	31.38 (797)	13.71 (348)	17.68 (449)	3.74 (95)	3.97 (101)	32.4
		3	230	1.5	■	29.89 (759)	12.21 (310)	17.68 (449)	3.74 (95)	3.97 (101)	28.8
			460	1.5	■	29.89 (759)	12.21 (310)	17.68 (449)	3.74 (95)	3.97 (101)	28.8
16S20-18	366	1	230	2	•	40.48 (1028)	19.49 (495)	20.99 (533)	3.74 (95)	3.97 (101)	36.0
		3	230	2	■	34.69 (881)	13.71 (348)	20.99 (533)	3.74 (95)	3.97 (101)	36.0
			460	2	■	34.69 (881)	13.71 (348)	20.99 (533)	3.74 (95)	3.97 (101)	36.0
16S30-24	487	1	230	3	•	48.55 (1233)	22.60 (574)	25.95 (659)	3.74 (95)	3.97 (101)	62.1
		3	230	3	•	43.94 (1116)	18.00 (457)	25.95 (659)	3.74 (95)	3.97 (101)	57.6
			460	3	•	43.94 (1116)	18.00 (457)	25.95 (659)	3.74 (95)	3.97 (101)	57.6
16S50-38	814	1	230	5	•	65.91 (1674)	26.62 (676)	39.30 (998)	3.74 (95)	3.97 (101)	97.2
		3	230	5	•	62.01 (1575)	22.72 (577)	39.30 (998)	3.74 (95)	3.97 (101)	90.0
			460	5	•	62.01 (1575)	22.72 (577)	39.30 (998)	3.74 (95)	3.97 (101)	90.0
SP 16S, motor dia. 6 inch, 3 wire motor, 60 Hz - rated flow 16 gpm (1.25" NPT)											
16S75-56DS	1200	3	230	7.5	▲	95.40 (2423)	26.62 (676)	68.78 (1747)	5.63 (143)	5.51 (140)	165.1
			460	7.5	▲	95.40 (2423)	26.62 (676)	68.78 (1747)	5.63 (143)	5.51 (140)	165.1
16S100-75DS	1607	3	460	10	▲	115.08 (2923)	30.60 (777)	84.49 (2146)	5.63 (143)	5.51 (140)	190.0

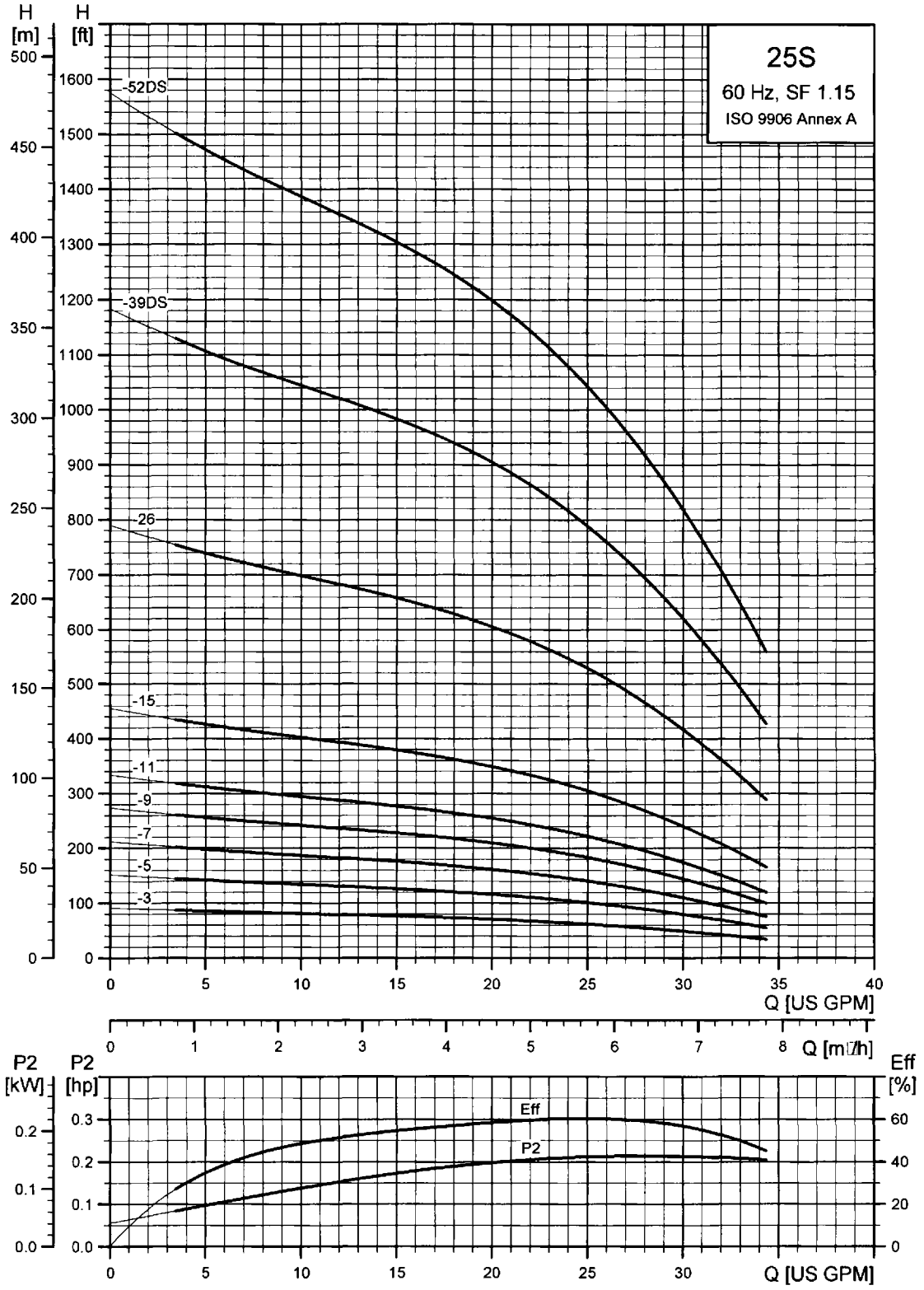
Notes:
Control box is required for 3-wire, single-phase applications. Data does not include control box.
DS designation = Built into sleeve, 1-1/4" NPT, 6" minimum well diameter.
■ MS402 motor.
• MS4000 motor.
▲ MS6 motor.
∧ MMS6000 motor.
★ MMS8000 motor.
♦ Takes MS6 motor; not available as complete.
☼ Takes MMS6000 motor; not available as complete.
* Takes MMS8000 motor; not available as complete.
† Takes MMS10000 motor; not available as complete.

16S



E = Maximum diameter of pump including cable guard and motor.

25S (25 gpm)

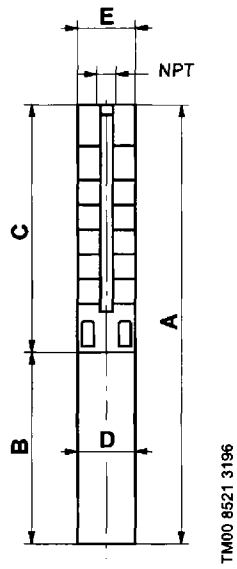


TM05 0232 0112

25S (25 gpm)

Pump model	Nom. head [ft]	Ph	Volts [V]	Motor [Hp]		Dimensions A [in (mm)]	B [in (mm)]	C [in (mm)]	D [in (mm)]	E [in (mm)]	Net weight (complete) [lb]
25S, motor dia. 4 inch, 2 wire motor, 60 Hz - rated flow 25 gpm (1.5" NPT)											
25S05-3	60	1	115	.5	■	19.61 (498)	11.03 (280)	8.59 (218)	3.74 (95)	3.97 (101)	21.6
			230	.5	■	19.61 (498)	11.03 (280)	8.59 (218)	3.74 (95)	3.97 (101)	21.6
25S07-5	99	1	230	.75	■	21.86 (555)	11.62 (295)	10.24 (260)	3.74 (95)	3.97 (101)	23.4
25S10-7	139	1	230	1	■	24.10 (612)	12.21 (310)	11.89 (302)	3.74 (95)	3.97 (101)	25.2
25S15-9	179	1	230	1.5	■	27.25 (692)	13.71 (348)	13.55 (344)	3.74 (95)	3.97 (101)	28.8
25S, motor dia. 4 inch, 3 wire motor, 60 Hz - rated flow 25 gpm (1.5" NPT)											
25S05-3	60	1	115	.5	■	19.61 (498)	11.03 (280)	8.59 (218)	3.74 (95)	3.97 (101)	21.6
			230	.5	■	19.61 (498)	11.03 (280)	8.59 (218)	3.74 (95)	3.97 (101)	21.6
25S07-5	99	1	230	.75	■	21.86 (555)	11.62 (295)	10.24 (260)	3.74 (95)	3.97 (101)	23.4
25S10-7	139	1	230	1	■	24.10 (612)	12.21 (310)	11.89 (302)	3.74 (95)	3.97 (101)	25.2
25S15-9	179	1	230	1.5	■	27.25 (692)	13.71 (348)	13.55 (344)	3.74 (95)	3.97 (101)	29.7
		3	230	1.5	■	25.75 (654)	12.21 (310)	13.55 (344)	3.74 (95)	3.97 (101)	27.0
			460	1.5	■	25.75 (654)	12.21 (310)	13.55 (344)	3.74 (95)	3.97 (101)	28.8
25S20-11	219	1	230	2	•	34.69 (881)	19.49 (495)	15.20 (386)	3.74 (95)	3.97 (101)	33.1
		3	230	2	■	28.90 (734)	13.71 (348)	15.20 (386)	3.74 (95)	3.97 (101)	37.0
			460	2	■	28.90 (734)	13.71 (348)	15.20 (386)	3.74 (95)	3.97 (101)	33.3
25S30-15	298	1	230	3	•	41.11 (1044)	22.60 (574)	18.51 (470)	3.74 (95)	3.97 (101)	61.2
		3	230	3	•	36.50 (927)	18.00 (457)	18.51 (470)	3.74 (95)	3.97 (101)	53.1
			460	3	•	36.50 (927)	18.00 (457)	18.51 (470)	3.74 (95)	3.97 (101)	53.1
25S50-26	517	1	230	5	•	54.22 (1377)	26.62 (676)	27.60 (701)	3.74 (95)	3.97 (101)	72.9
		3	230	5	•	50.32 (1278)	22.72 (577)	27.60 (701)	3.74 (95)	3.97 (101)	72.9
			460	5	•	50.32 (1278)	22.72 (577)	27.60 (701)	3.74 (95)	3.97 (101)	72.9
SP 25S, motor dia. 6 inch, 3 wire motor, 60 Hz - rated flow 25 gpm (1.5" NPT)											
25S75-39DS	775	3	230	7.5	▲	64.81 (1646)	22.25 (565)	42.56 (1081)	5.63 (143)	5.43 (138)	122.1
			460	7.5	▲	64.81 (1646)	22.25 (565)	42.56 (1081)	5.63 (143)	5.43 (138)	122.1
25S100-52DS	1034	3	460	10	▲	88.71 (2253)	23.23 (590)	65.48 (1663)	5.63 (143)	5.51 (140)	163.1

25S

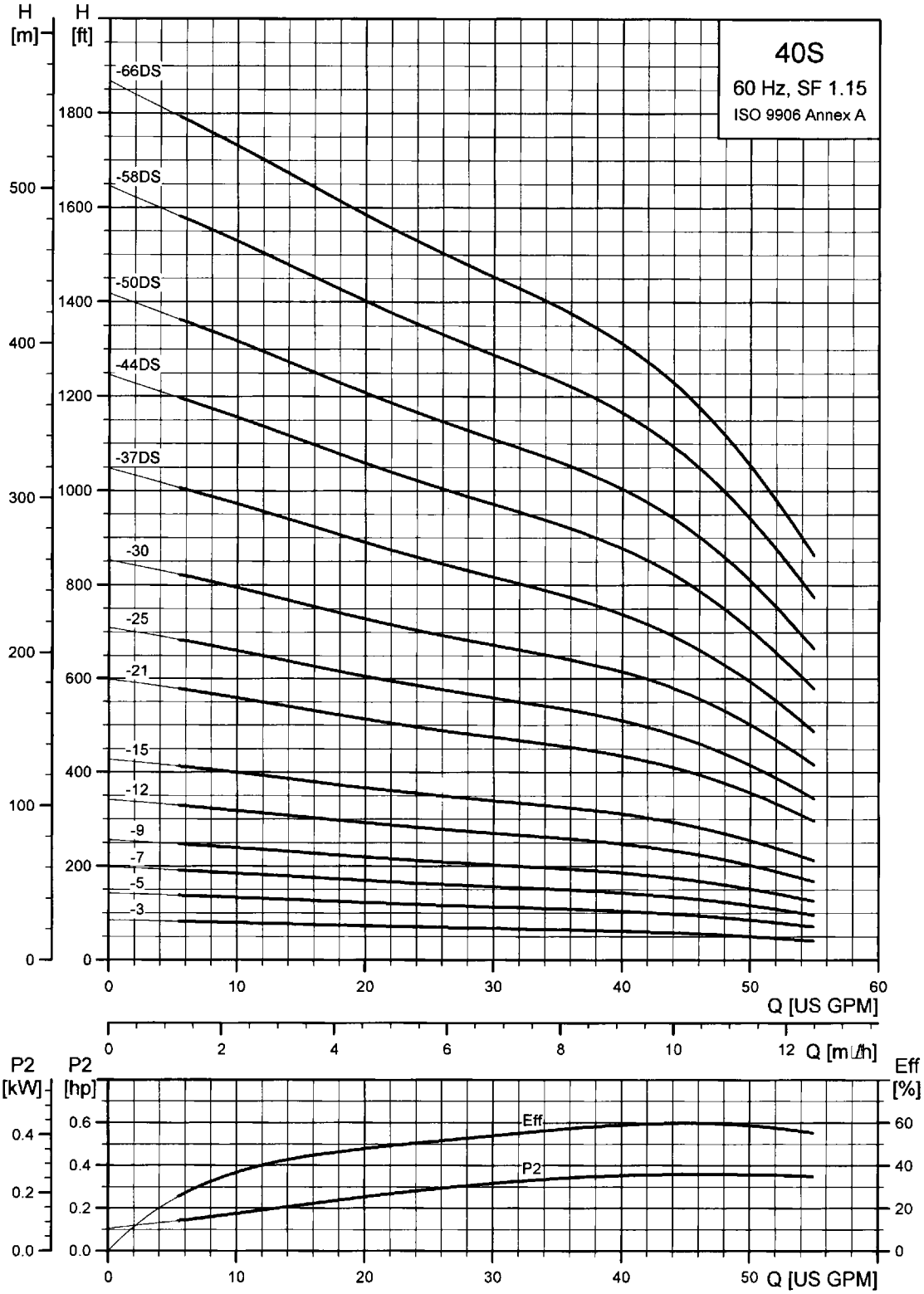


E = Maximum diameter of pump including cable guard and motor.

Notes:
Control box is required for 3-wire, single-phase applications. Data does not include control box.
DS designation = Built into sleeve, 1-1/2" NPT, 6" minimum well diameter.

- ■ MS402 motor.
- • MS4000 motor.
- ▲ MS6 motor.
- ∧ MMS6000 motor.
- ★ MMS8000 motor.
- ♦ Takes MS6 motor; not available as complete.
- ☼ Takes MMS6000 motor; not available as complete.
- * Takes MMS8000 motor; not available as complete.
- † Takes MMS10000 motor; not available as complete.

40S (40 gpm)



TM05 0233 0112

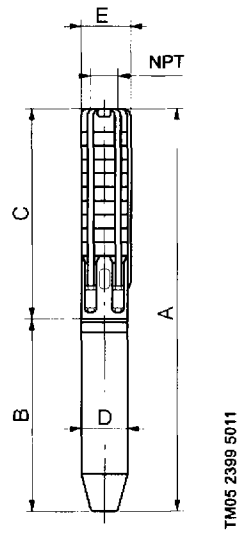
40S (40 gpm)

Pump model	Nom. head [ft]	Ph	Volts [V]	Motor [Hp]		Dimensions A [in (mm)]	B [in (mm)]	C [in (mm)]	D [in (mm)]	E [in (mm)]	Net weight (complete) [lb]
40S - Motor dia. 4 inch, 2 wire motor, 60 Hz, rated flow 40 gpm (2" NPT)											
40S10-3	60	1	230	1	■	25.00 (635)	12.21 (310)	12.80 (325)	3.74 (95)	3.97 (101)	26.1
40S10-5	102	1	230	1.5	■	29.81 (757)	13.71 (348)	16.11 (409)	3.74 (95)	3.97 (101)	30.6
40S - Motor dia. 4 inch, 3 wire motor, 60 Hz, rated flow 40 gpm (2" NPT)											
40S10-3	61	1	230	1	■	25.00 (635)	12.21 (310)	12.8 (325)	3.74 (95)	3.97 (101)	26.1
40S15-5	102	1	230	1.5	■	29.81 (757)	13.71 (348)	16.11 (409)	3.74 (95)	3.97 (101)	30.6
		3	230	1.5	■	28.31 (719)	12.21 (310)	16.11 (409)	3.74 (95)	3.97 (101)	30.6
			460	1.5	■	28.31 (719)	12.21 (310)	16.11 (409)	3.74 (95)	3.97 (101)	30.6
40S20-7	143	1	230	2	•	38.90 (988)	19.49 (495)	19.41 (493)	3.74 (95)	3.97 (101)	36.9
		3	230	2	■	33.12 (841)	13.71 (348)	19.41 (493)	3.74 (95)	3.97 (101)	36.9
			460	2	■	33.12 (841)	13.71 (348)	19.41 (493)	3.74 (95)	3.97 (101)	36.9
40S30-9	184	1	230	3	•	45.32 (1151)	22.60 (574)	22.72 (577)	3.74 (95)	3.97 (101)	74.1
		3	230	3	•	40.71 (1034)	18.00 (457)	22.72 (577)	3.74 (95)	3.97 (101)	81.0
			460	3	•	40.71 (1034)	18.00 (457)	22.72 (577)	3.74 (95)	3.97 (101)	74.7
40S50-12	245	1	230	5	•	54.30 (1379)	26.62 (676)	27.68 (703)	3.74 (95)	3.97 (101)	81.0
		3	230	5	•	50.40 (1280)	22.72 (577)	27.68 (703)	3.74 (95)	3.97 (101)	74.7
			460	5	•	50.40 (1280)	22.72 (577)	27.68 (703)	3.74 (95)	3.97 (101)	74.7
40S50-15	307	1	230	5	•	59.26 (1505)	26.62 (676)	32.64 (829)	3.74 (95)	3.97 (101)	80.1
		3	230	5	•	55.36 (1406)	22.72 (577)	32.64 (829)	3.74 (95)	3.97 (101)	80.1
			460	5	•	55.36 (1406)	22.72 (577)	32.64 (829)	3.74 (95)	3.97 (101)	80.1
40S - Motor dia. 6 inch, 3 wire motor, 60 Hz, rated flow 40 gpm (2" NPT)											
40S75-21	429	3	230	7.5	•	69.22 (1758)	26.66 (677)	42.56 (1081)	3.74 (95)	3.97 (101)	113.3
			460	7.5	•	69.22 (1758)	26.66 (677)	42.56 (1081)	3.74 (95)	3.97 (101)	113.3
40S75-25	511	3	230	7.5	•	75.83 (1926)	26.66 (677)	49.18 (1249)	3.74 (95)	3.97 (101)	92.4
			460	7.5	•	75.83 (1926)	26.66 (677)	49.18 (1249)	3.74 (95)	3.97 (101)	92.4
40S100-30	613	3	460	10	•	88.04 (2236)	30.60 (777)	57.45 (1459)	3.74 (95)	3.97 (101)	166.0
40S150-37DS	756	3	230	15	▲	99.34 (2523)	27.88 (708)	71.46 (1815)	5.63 (143)	5.43 (138)	151.9
			460	15	▲	99.34 (2523)	27.88 (708)	71.46 (1815)	5.63 (143)	5.43 (138)	151.9
40S150-44DS	899	3	230	15	▲	110.91 (2817)	27.88 (708)	83.04 (2109)	5.63 (143)	5.43 (138)	165.1
			460	15	▲	110.91 (2817)	27.88 (708)	83.04 (2109)	5.63 (143)	5.43 (138)	151.9
40S200-50DS	1022	3	230	20	▲	136.23 (3460)	30.83 (783)	105.4 (2677)	5.63 (143)	5.51 (140)	226.9
			460	20	▲	136.23 (3460)	30.83 (783)	105.4 (2677)	5.63 (143)	5.51 (140)	226.9
40S200-58DS	1186	3	230	20	▲	149.45 (3796)	30.83 (783)	118.63 (3013)	5.63 (143)	5.51 (140)	251.1
			460	20	▲	149.45 (3796)	30.83 (783)	118.63 (3013)	5.63 (143)	5.51 (140)	251.1
40S200-66DS	1349	3	230	20	▲	162.68 (4132)	30.83 (783)	131.86 (3349)	5.63 (143)	5.51 (140)	266.5
			460	20	▲	162.68 (4132)	30.83 (783)	131.86 (3349)	5.63 (143)	5.51 (140)	266.5

Notes:
Control box is required for 3-wire, single-phase applications. Data does not include control box.
DS designation = Built into sleeve, 2" NPT, 6" minimum well diameter.

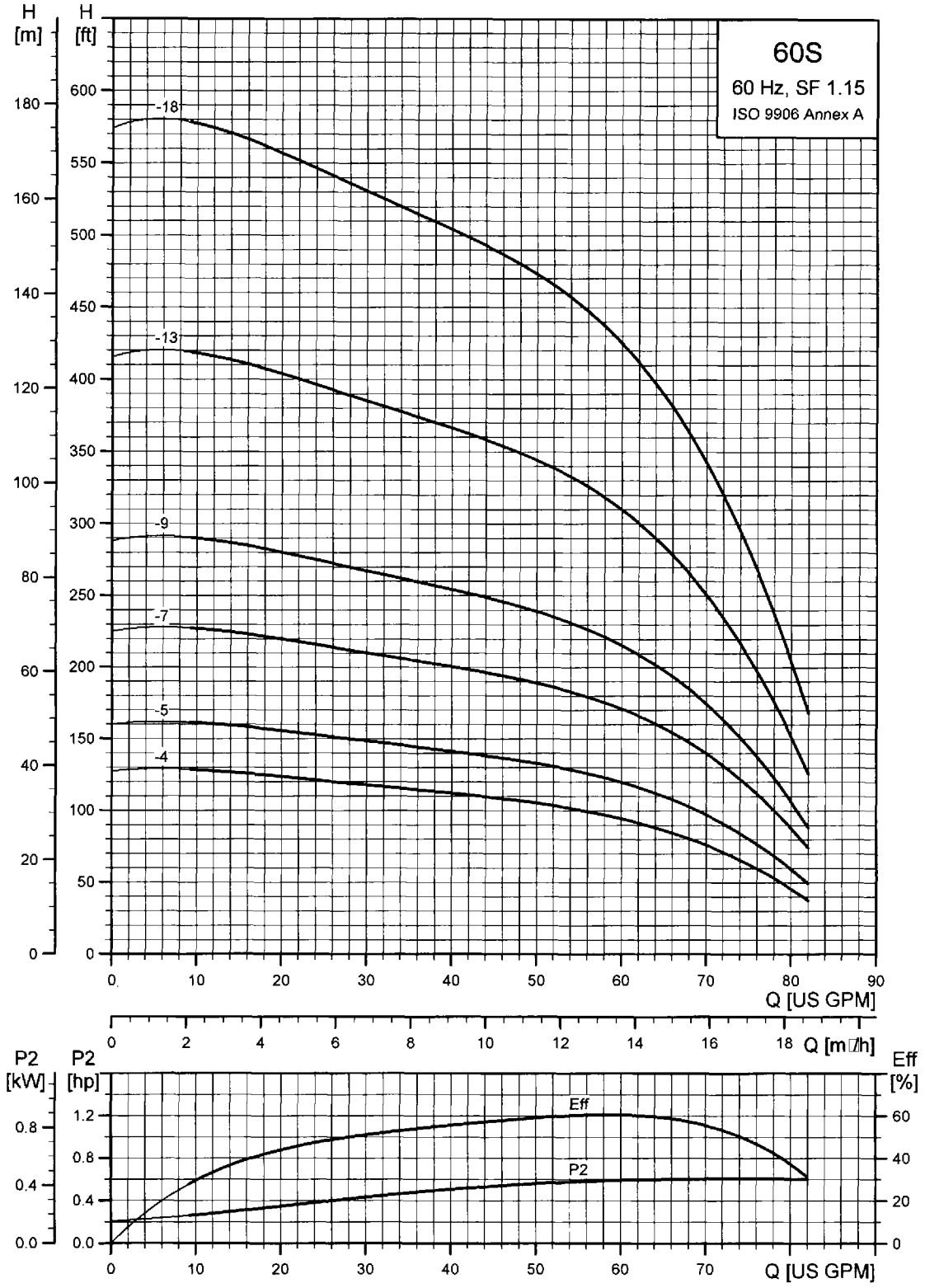
- ■ MS402 motor.
- • MS4000 motor.
- ▲ MS6 motor.
- ∧ MMS6000 motor.
- ★ MMS8000 motor.
- ♦ Takes MS6 motor; not available as complete.
- ☼ Takes MMS6000 motor; not available as complete.
- * Takes MMS8000 motor; not available as complete.
- † Takes MMS10000 motor; not available as complete.

40S



E = Maximum diameter of pump including cable guard and motor.

60S (60 gpm)



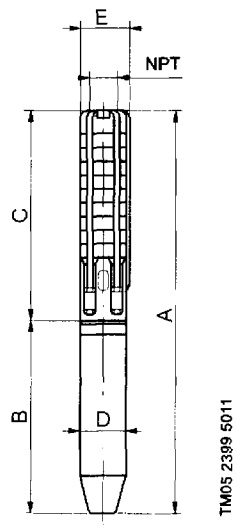
TM05 1736 0112

60S (60 gpm)

Pump model	Nom. head [ft]	Ph	Volts [V]	Motor [Hp]		Dimensions A [in (mm)]	B [in (mm)]	C [in (mm)]	D [in (mm)]	E [in (mm)]	Net weight (complete) [lb]
60S - Motor dia. 4 inch, 3 wire motor, 60 Hz, rated flow 60 gpm (2" NPT)											
60S20-4	93	1	230	2	•	37.01 (940)	19.49 (495)	17.52 (445)	3.74 (95)	3.97 (101)	36.0
		3	230	2	■	31.23 (793)	13.71 (348)	17.52 (445)	3.74 (95)	3.97 (101)	36.0
			460	2	■	31.23 (793)	13.71 (348)	17.52 (445)	3.74 (95)	3.97 (101)	36.0
60S30-5	117	1	230	3	•	42.68 (1084)	22.60 (574)	20.08 (510)	3.74 (95)	3.97 (101)	61.2
		3	230	3	•	38.08 (967)	18.00 (457)	20.08 (510)	3.74 (95)	3.97 (101)	49.5
			460	3	•	38.08 (967)	18.00 (457)	20.08 (510)	3.74 (95)	3.97 (101)	58.5
60S50-7	164	1	230	5	•	51.82 (1316)	26.62 (676)	25.20 (640)	3.74 (95)	3.97 (101)	81.0
		3	230	5	•	47.92 (1217)	22.72 (577)	25.20 (640)	3.74 (95)	3.97 (101)	49.5
			460	5	•	47.92 (1217)	22.72 (577)	25.20 (640)	3.74 (95)	3.97 (101)	72.0
60S50-9	210	1	230	5	•	56.93 (1446)	26.62 (676)	30.32 (770)	3.74 (95)	3.97 (101)	85.5
		3	230	5	•	53.04 (1347)	22.72 (577)	30.32 (770)	3.74 (95)	3.97 (101)	76.5
			460	5	•	53.04 (1347)	22.72 (577)	30.32 (770)	3.74 (95)	3.97 (101)	76.5
60S75-13	304	3	230	7.5	•	67.21 (1707)	26.66 (677)	40.56 (1030)	3.74 (95)	3.97 (101)	83.3
			460	7.5	•	67.21 (1707)	26.66 (677)	40.56 (1030)	3.74 (95)	3.97 (101)	136.8
60S100-18	420	3	460	10	•	83.94 (2132)	30.60 (777)	53.35 (1355)	3.74 (95)	3.97 (101)	175.5

60S - Motor dia. 6 inch, 3 wire motor, 60 Hz, rated flow 60 gpm (2" NPT)											
60S75-13	304	3	230	7.5	▲	65.24 (1657)	22.25 (565)	43.00 (1092)	5.63 (143)	5.43 (138)	136.8
			460	7.5	▲	65.24 (1657)	22.25 (565)	43.00 (1092)	5.63 (143)	5.43 (138)	136.8
60S100-18	420	3	230	10	▲	79.02 (2007)	23.23 (590)	55.79 (1417)	5.63 (143)	5.43 (138)	207.0
			460	10	▲	79.02 (2007)	23.23 (590)	55.79 (1417)	5.63 (143)	5.43 (138)	207.0

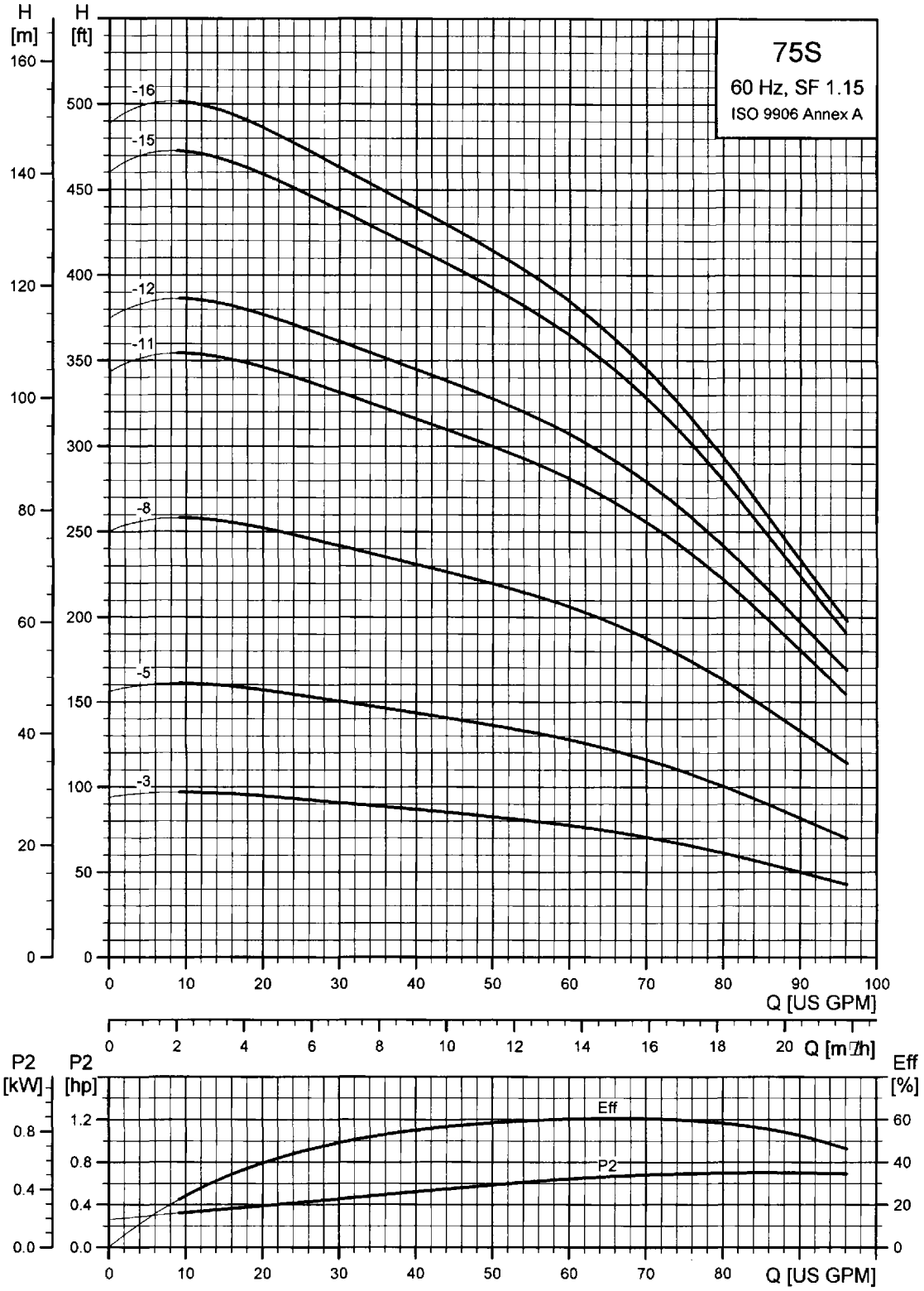
60S



E = Maximum diameter of pump including cable guard and motor.

Notes:
Control box is required for 3-wire, single-phase applications. Data does not include control box.diameter.
■ MS402 motor.
• MS4000 motor.
▲ MS6 motor.
∧ MMS6000 motor.
★ MMS8000 motor.
♦ Takes MS6 motor; not available as complete.
☼ *Takes MMS6000 motor; not available as complete.*
* Takes MMS8000 motor; not available as complete.
† Takes MMS10000 motor; not available as complete.

75S (75 gpm)

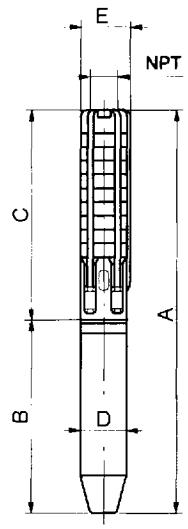


TM05 0234 0112

75S (75 gpm)

Pump model	Nom. head [ft]	Ph	Volts [V]	Motor [Hp]		Dimensions A [in (mm)]	B [in (mm)]	C [in (mm)]	D [in (mm)]	E [in (mm)]	Net weight (complete) [lb]
75S - Motor dia. 4 inch, 3 wire motor, 60 Hz, rated flow 75 gpm (2" NPT)											
75S20-3	68	1	230	2	•	34.45 (875)	19.49 (495)	14.97 (380)	3.74 (95)	3.97 (101)	36.9
		3	230	2	■	28.67 (728)	13.71 (348)	14.97 (380)	3.74 (95)	3.97 (101)	34.2
			460	2	■	28.67 (728)	13.71 (348)	14.97 (380)	3.74 (95)	3.97 (101)	34.2
75S30-5	114	1	230	3	•	42.68 (1084)	22.60 (574)	20.08 (510)	3.74 (95)	3.97 (101)	69.3
		3	230	3	•	38.08 (967)	18.00 (457)	20.08 (510)	3.74 (95)	3.97 (101)	57.6
			460	3	•	38.08 (967)	18.00 (457)	20.08 (510)	3.74 (95)	3.97 (101)	57.6
75S50-8	182	1	230	5	•	54.38 (1381)	26.62 (676)	27.76 (705)	3.74 (95)	3.97 (101)	87.3
		3	230	5	•	50.48 (1282)	22.72 (577)	27.76 (705)	3.74 (95)	3.97 (101)	74.7
			460	5	•	50.48 (1282)	22.72 (577)	27.76 (705)	3.74 (95)	3.97 (101)	74.7
75S75-12	273	3	230	7.5	•	64.65 (1642)	26.66 (677)	38.00 (965)	3.74 (95)	3.97 (101)	81.4
			460	7.5	•	64.65 (1642)	26.66 (677)	38.00 (965)	3.74 (95)	3.97 (101)	81.4
75S100-16	364	3	460	10	•	78.82 (2002)	30.60 (777)	48.23 (1225)	3.74 (95)	3.97 (101)	138.0
75S - Motor dia. 6 inch, 3 wire motor, 60 Hz, rated flow 75 gpm (2" NPT)											
75S75-11	250	3	230	7.5	▲	60.12 (1527)	22.25 (565)	37.88 (962)	5.63 (143)	5.43 (138)	130.5
			460	7.5	▲	60.12 (1527)	22.25 (565)	37.88 (962)	5.63 (143)	5.43 (138)	130.5
75S100-15	341	3	230	10	▲	70.16 (1782)	23.23 (590)	46.93 (1192)	5.63 (143)	5.43 (138)	175.5
			460	10	▲	70.16 (1782)	23.23 (590)	46.93 (1192)	5.63 (143)	5.43 (138)	175.5

75S

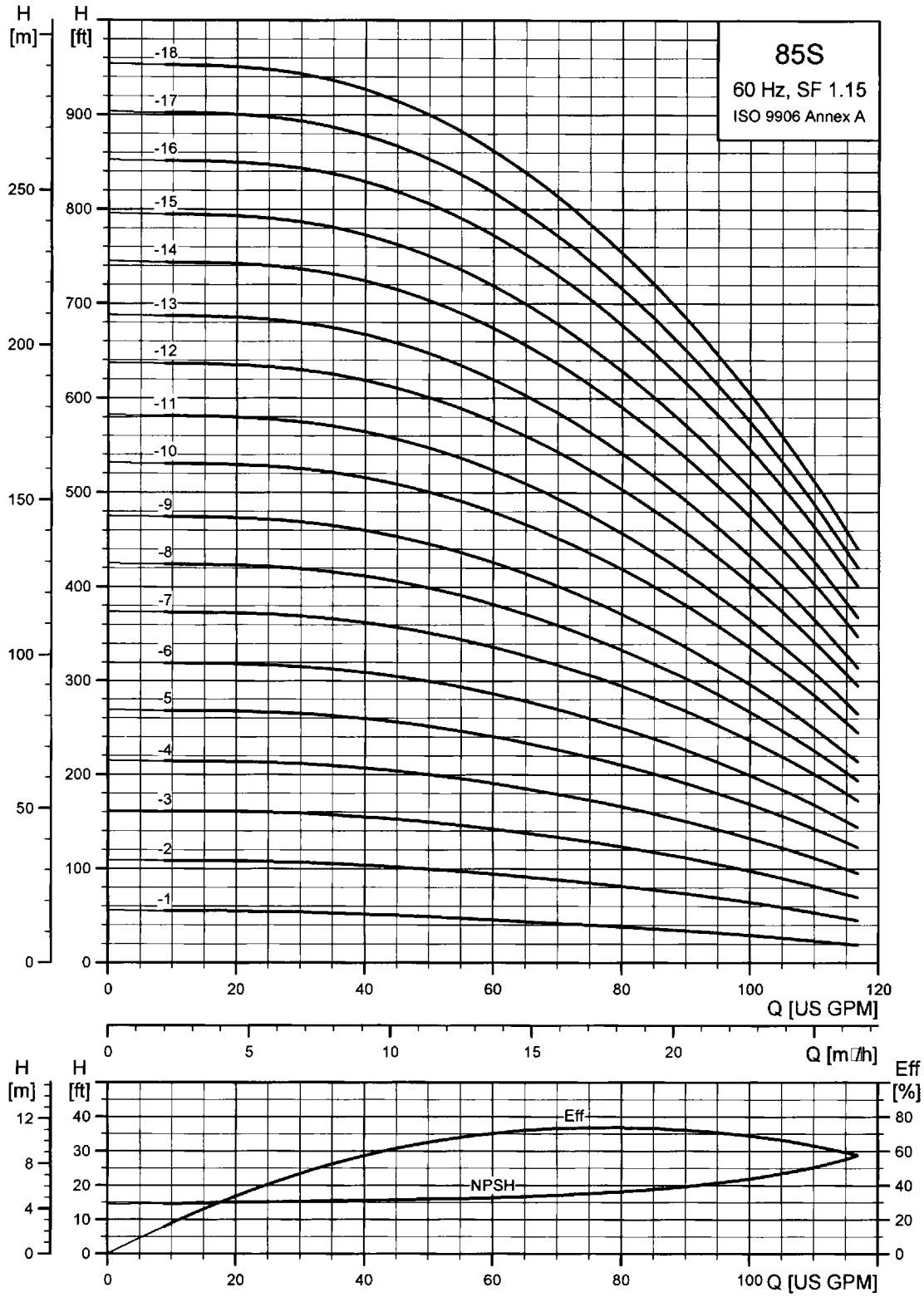


TM05 2399 5011

E = Maximum diameter of pump including cable guard and motor.

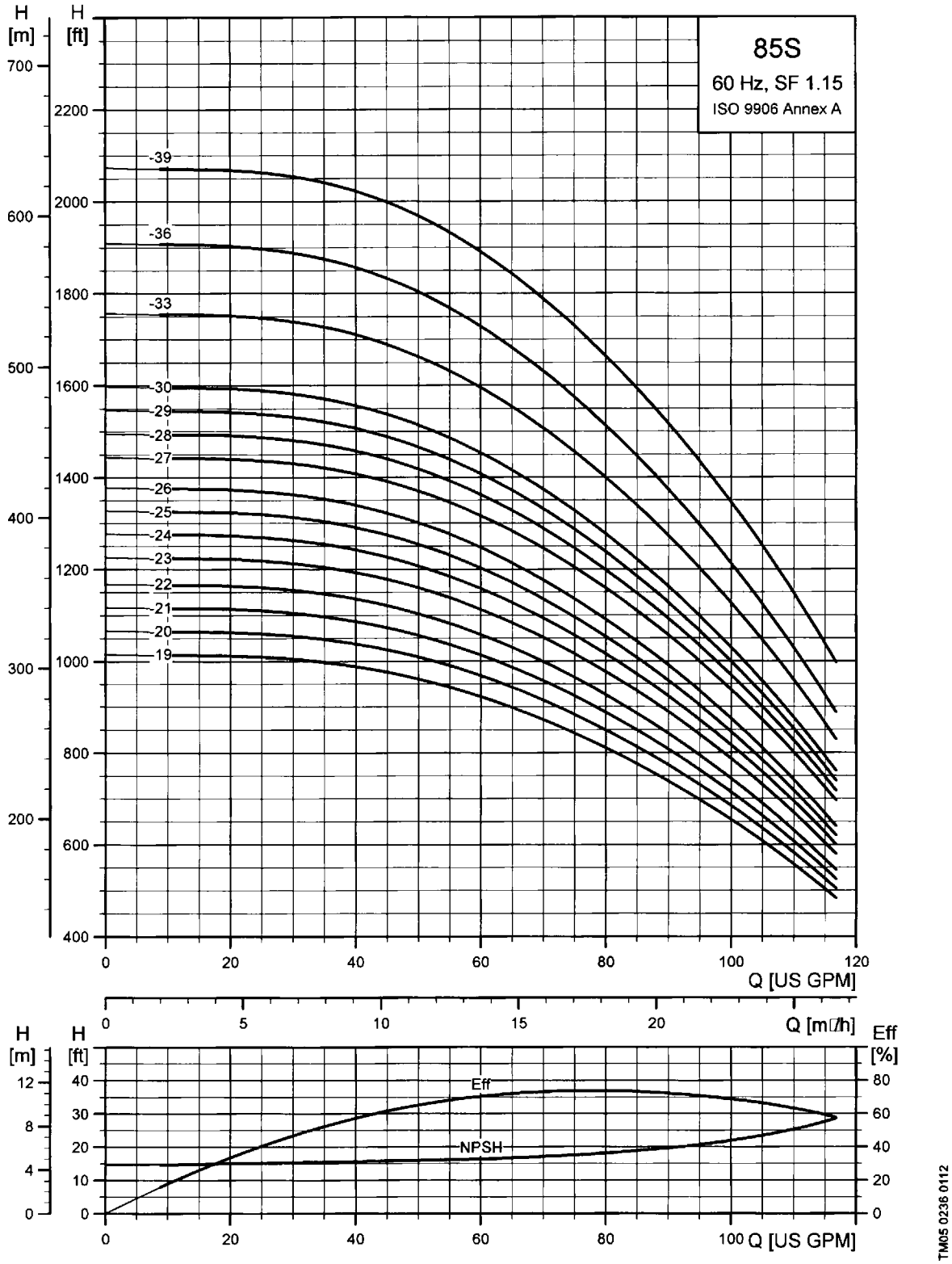
Notes:
Control box is required for 3-wire, single-phase applications. Data does not include control box.
■ MS402 motor.
• MS4000 motor.
▲ MS6 motor.
∧ MMS6000 motor.
★ MMS8000 motor.
♦ Takes MS6 motor; not available as complete.
☼ Takes MMS6000 motor; not available as complete.
* Takes MMS8000 motor; not available as complete.
† Takes MMS10000 motor; not available as complete.

85S (85 gpm)

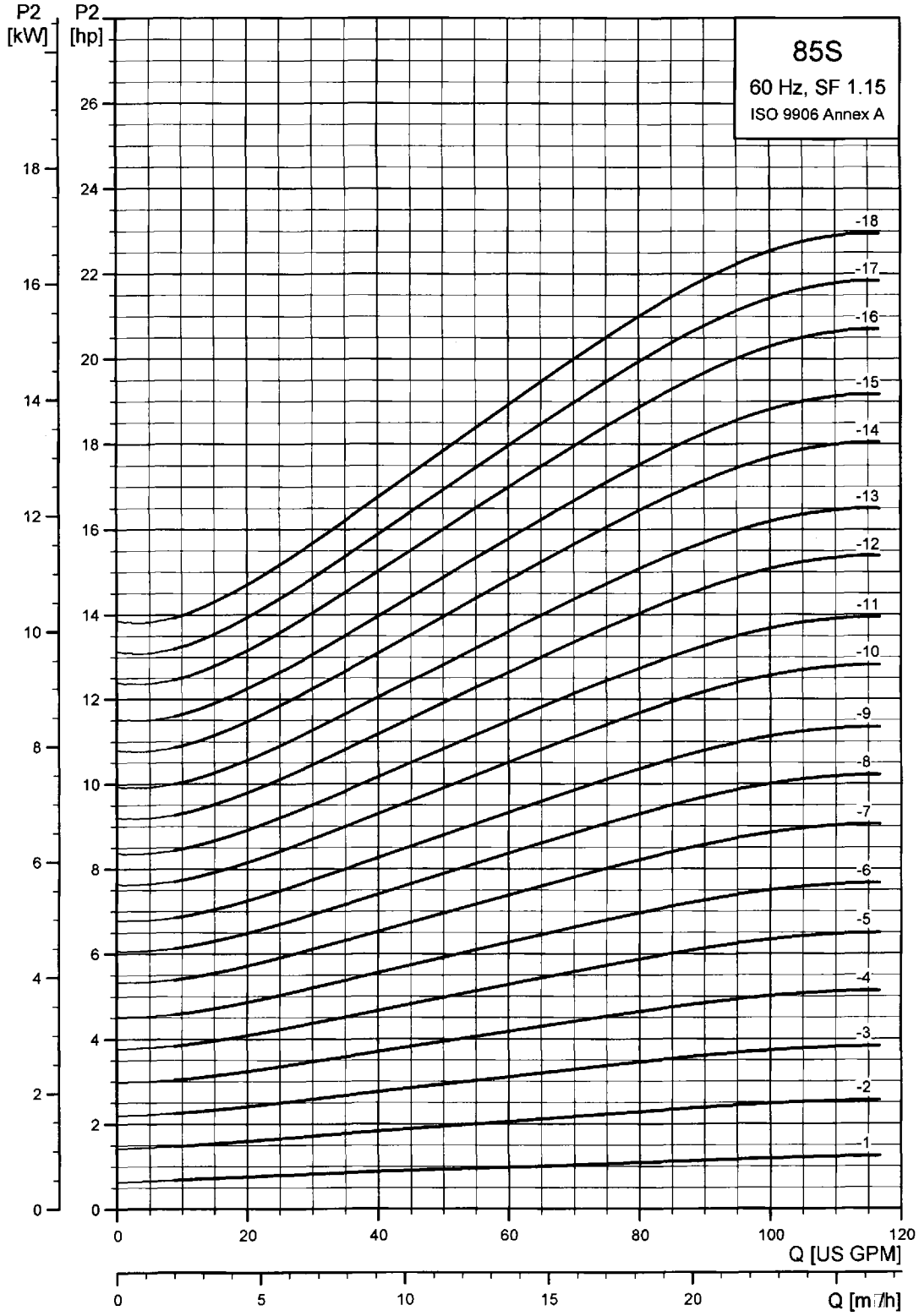


TM05 0235 0112

85S (85 gpm)

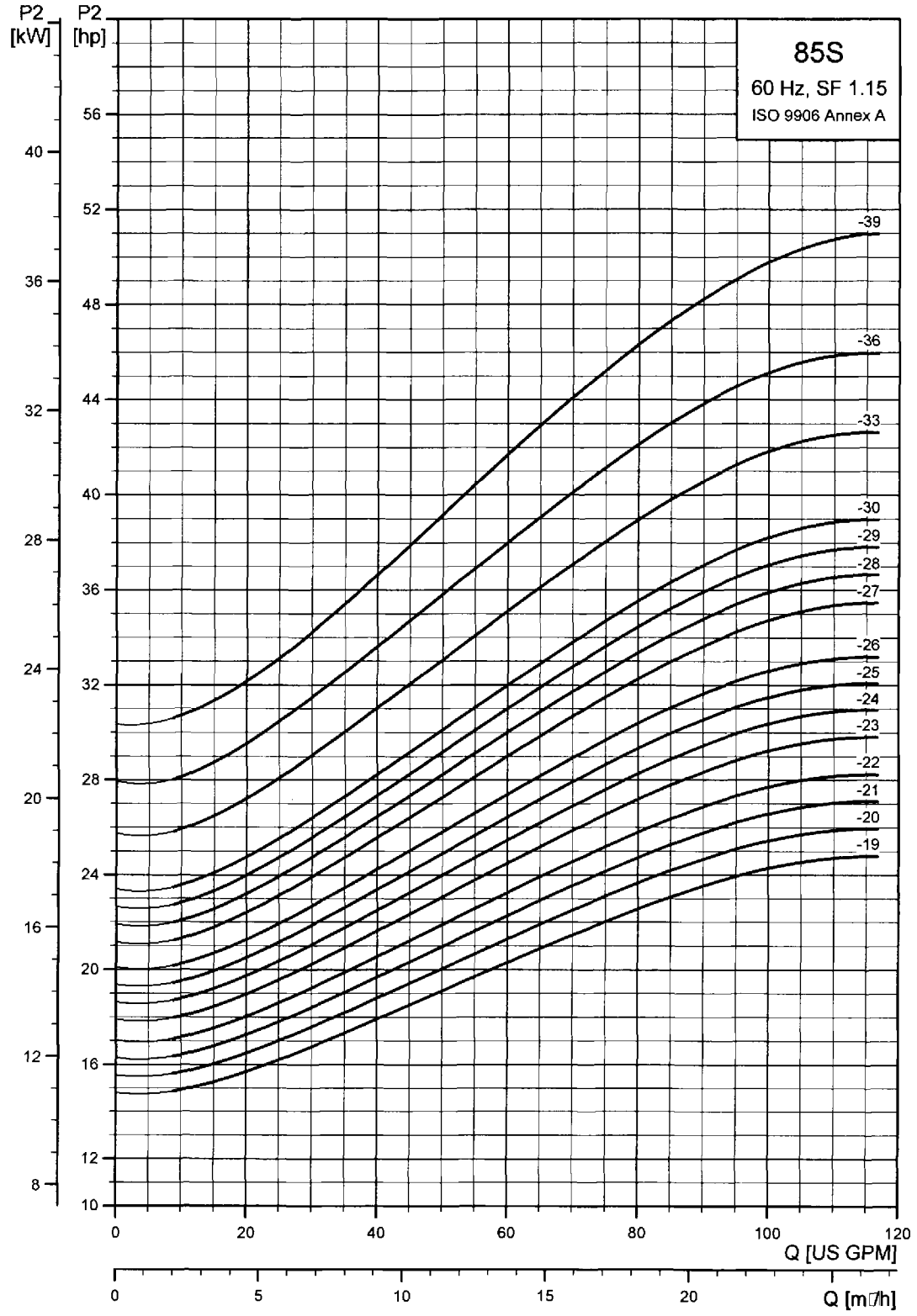

85S
60 Hz, SF 1.15
ISO 9906 Annex A
H [m]
H [ft]
-39
-36
-33
-30
-29
-28
-27
-26
-25
-24
-23
-22
-21
-20
-19
Q [US GPM]
Q [m3/h]
Eff [%]
Eff
NPSH
TM05 0236 0112

85S (85 gpm) pump power requirement (P2)



TM05 0237 0112

85S (85 gpm) pump power requirement (P2)



TM05 0238 0112

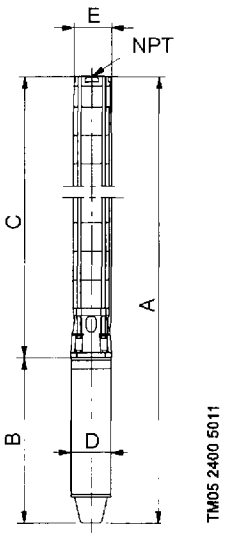
85S (85 gpm)

Pump model	Nom. head [ft]	Ph	Volts [V]	Motor [Hp]		Dimensions A [in (mm)]	B [in (mm)]	C [in (mm)]	D [in (mm)]	E [in (mm)]	Net weight (complete) [lb]
85S - Motor dia. 4 inch, 3 wire motor, 60 Hz, rated flow 85 gpm (3" NPT)											
85S15-1	35	1	230	1.5	■	27.60 (701)	15.24 (387)	12.36 (314)	3.74 (95)	5.16 (131)	29.7
		3	230	1.5	■	26.02 (661)	13.66 (347)	12.36 (314)	3.74 (95)	5.16 (131)	29.7
		3	460	1.5	■	26.02 (661)	13.66 (347)	12.36 (314)	3.74 (95)	5.16 (131)	29.7
85S30-2	74	1	230	3	•	32.69 (951)	22.72 (577)	14.72 (374)	3.74 (95)	5.16 (131)	55.8
		3	230	3	•	32.69 (830)	17.96 (456)	14.72 (374)	3.74 (95)	5.16 (131)	47.7
		3	460	3	•	32.69 (830)	17.96 (456)	14.72 (374)	3.74 (95)	5.16 (131)	47.7
85S50-3	114	1	230	5	•	43.78 (1112)	26.65 (677)	17.13 (435)	3.74 (95)	5.16 (131)	67.5
		3	230	5	•	39.80 (1011)	22.69 (576)	17.13 (435)	3.74 (95)	5.16 (131)	51.3
		3	460	5	•	39.80 (1011)	22.69 (576)	17.13 (435)	3.74 (95)	5.16 (131)	51.3
85S50-4	154	1	230	5	•	43.78 (1112)	26.65 (677)	17.13 (435)	3.74 (95)	5.16 (131)	69.3
		3	230	5	•	39.80 (1011)	22.69 (576)	17.13 (435)	3.74 (95)	5.16 (131)	61.2
		3	460	5	•	39.80 (1011)	22.69 (576)	17.13 (435)	3.74 (95)	5.16 (131)	61.2
85S75-5	194	3	230	7.5	•	48.50 (1232)	26.62 (676)	21.89 (556)	3.74 (95)	5.16 (131)	73.8
		3	460	7.5	•	48.50 (1232)	26.62 (676)	21.89 (556)	3.74 (95)	5.16 (131)	73.8
85S75-6	234	3	230	7.5	•	50.87 (1292)	26.62 (676)	24.25 (616)	3.74 (95)	5.16 (131)	85.5
		3	460	7.5	•	50.87 (1292)	26.62 (676)	24.25 (616)	3.74 (95)	5.16 (131)	76.5
85S100-7	274	3	460	10	•	57.21 (1453)	30.56 (776)	26.65 (677)	3.74 (95)	5.16 (131)	136.8
85S100-8	314	3	460	10	•	59.57 (1513)	30.56 (776)	29.02 (737)	3.74 (95)	5.16 (131)	138.6
85S100-9	353	3	460	10	•	61.98 (1574)	30.56 (776)	31.42 (798)	3.74 (95)	5.16 (131)	140.4

85S - Motor dia. 6 inch, 3 wire motor, 60 Hz, rated flow 85 gpm (3" NPT)											
85S75-5	194	3	230	7.5	▲	44.76 (1137)	22.52 (565)	22.52 (572)	5.63 (143)	5.59 (142)	98.1
		3	460	7.5	▲	44.76 (1137)	22.52 (565)	22.52 (572)	5.63 (143)	5.59 (142)	98.1
85S75-6	234	3	230	7.5	▲	47.12 (1197)	22.24 (565)	24.88 (632)	5.63 (143)	5.59 (142)	99.9
		3	460	7.5	▲	47.12 (1197)	22.24 (565)	24.88 (632)	5.63 (143)	5.59 (142)	99.9
85S100-7	274	3	230	10	▲	50.51 (1283)	23.23 (590)	27.28 (693)	5.63 (143)	5.59 (142)	103.5
		3	460	10	▲	50.51 (1283)	23.23 (590)	27.28 (693)	5.63 (143)	5.59 (142)	103.5
85S100-8	314	3	230	10	▲	52.87 (1343)	23.23 (590)	29.65 (753)	5.63 (143)	5.59 (142)	105.3
		3	460	10	▲	52.87 (1343)	23.23 (590)	29.65 (753)	5.63 (143)	5.59 (142)	105.3
85S100-9	353	3	230	10	▲	55.28 (1404)	23.23 (590)	32.05 (814)	5.63 (143)	5.60 (142)	108.0
		3	460	10	▲	55.28 (1404)	23.23 (590)	32.05 (814)	5.63 (143)	5.60 (142)	108.0
85S150-10	393	3	230	15	▲	62.29 (1582)	27.88 (708)	34.41 (874)	5.63 (143)	5.60 (142)	122.4
		3	460	15	▲	62.29 (1582)	27.88 (708)	34.41 (874)	5.63 (143)	5.60 (142)	122.4
85S150-11	433	3	230	15	▲	64.69 (1643)	27.88 (708)	36.82 (935)	5.63 (143)	5.60 (142)	126.0
		3	460	15	▲	64.69 (1643)	27.88 (708)	36.82 (935)	5.63 (143)	5.60 (142)	126.0
85S150-12	473	3	230	15	▲	67.05 (1703)	27.88 (708)	39.18 (995)	5.63 (143)	5.60 (142)	133.2
		3	460	15	▲	67.05 (1703)	27.88 (708)	39.18 (995)	5.63 (143)	5.60 (142)	133.2
85S150-13	513	3	230	15	▲	69.45 (1764)	27.88 (708)	41.58 (1056)	5.63 (143)	5.60 (142)	135.0
		3	460	15	▲	69.45 (1764)	27.88 (708)	41.58 (1056)	5.63 (143)	5.60 (142)	135.0

Notes:
Control box is required for 3-wire, single-phase applications. Data does not include control box.
■ MS402 motor.
• MS4000 motor.
▲ MS6 motor.
∧ MMS6000 motor.
★ MMS8000 motor.
♦ Takes MS6 motor; not available as complete.
☼ Takes MMS6000 motor; not available as complete.
* Takes MMS8000 motor; not available as complete.
† Takes MMS10000 motor; not available as complete.

85S

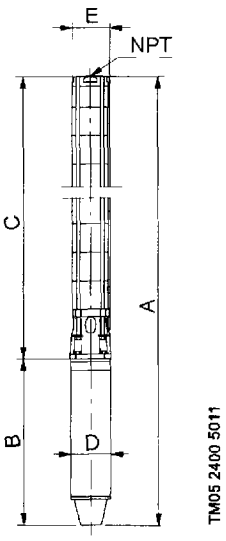


E = Maximum diameter of pump including cable guard and motor.

85S (85 gpm)

Pump model	Nom. head [ft]	Ph	Volts [V]	Motor [Hp]		Dimensions A [in (mm)]	B [in (mm)]	C [in (mm)]	D [in (mm)]	E [in (mm)]	Net weight (complete) [lb]
85S - Motor dia. 6 inch, 3 wire motor, 60 Hz, rated flow 85 gpm (3" NPT)											
85S200-14	533	3	230	20	▲	74.77 (1899)	30.83 (783)	43.94 (1116)	5.63 (143)	5.60 (142)	143.1
		3	460	20	▲	74.77 (1899)	30.83 (783)	43.94 (1116)	5.63 (143)	5.60 (142)	143.1
85S200-15	593	3	230	20	▲	77.17 (1960)	30.83 (783)	46.34 (1177)	5.63 (143)	5.60 (142)	147.6
		3	460	20	▲	77.17 (1960)	30.83 (783)	46.34 (1177)	5.63 (143)	5.60 (142)	147.6
85S200-16	633	3	230	20	▲	79.53 (2020)	30.83 (783)	48.71 (1237)	5.63 (143)	5.60 (142)	157.5
		3	460	20	▲	79.53 (2020)	30.83 (783)	48.71 (1237)	5.63 (143)	5.60 (142)	157.5
85S200-17	672	3	230	20	▲	81.93 (2081)	30.83 (783)	51.11 (1298)	5.63 (143)	5.60 (142)	160.2
		3	460	20	▲	81.93 (2081)	30.83 (783)	51.11 (1298)	5.63 (143)	5.60 (142)	160.2
85S200-18	712	3	230	20	▲	84.30 (2141)	30.83 (783)	53.47 (1358)	5.63 (143)	5.60 (142)	161.1
		3	460	20	▲	84.30 (2141)	30.83 (783)	53.47 (1358)	5.63 (143)	5.60 (142)	179.0
85S250-19	752	3	230	25	▲	88.86 (2257)	33.00 (838)	55.87 (1419)	5.63 (143)	5.60 (142)	191.7
		3	460	25	▲	88.86 (2257)	33.00 (838)	55.87 (1419)	5.63 (143)	5.60 (142)	191.7
85S250-20	792	3	230	25	▲	91.86 (2333)	33.00 (838)	58.86 (1495)	5.63 (143)	5.60 (142)	195.3
		3	460	25	▲	91.86 (2333)	33.00 (838)	58.86 (1495)	5.63 (143)	5.60 (142)	195.3
85S250-21	832	3	230	25	▲	94.26 (2394)	33.00 (838)	61.26 (1556)	5.63 (143)	5.60 (142)	198.0
		3	460	25	▲	94.26 (2394)	33.00 (838)	61.26 (1556)	5.63 (143)	5.60 (142)	198.0
85S250-22	872	3	230	25	▲	96.62 (2454)	33.00 (838)	63.63 (1616)	5.63 (143)	5.60 (142)	199.8
		3	460	25	▲	96.62 (2454)	33.00 (838)	63.63 (1616)	5.63 (143)	5.60 (142)	199.8
85S300-23	912	3	230	30	▲	101.54 (2579)	35.56 (903)	65.99 (1676)	5.63 (143)	5.60 (142)	199.8
		3	460	30	▲	101.54 (2579)	35.56 (903)	65.99 (1676)	5.63 (143)	5.60 (142)	199.8
85S300-24	952	3	230	30	▲	103.94 (2640)	35.56 (903)	68.39 (1737)	5.63 (143)	5.60 (142)	216.0
		3	460	30	▲	103.94 (2640)	35.56 (903)	68.39 (1737)	5.63 (143)	5.60 (142)	216.0
85S300-25	991	3	230	30	▲	106.34 (2701)	35.56 (903)	70.79 (1798)	5.63 (143)	5.60 (142)	219.6
		3	460	30	▲	106.34 (2701)	35.56 (903)	70.79 (1798)	5.63 (143)	5.60 (142)	219.6
85S300-26	1031	3	230	30	▲	108.71 (2761)	35.56 (903)	73.15 (1858)	5.63 (143)	5.60 (142)	221.4
		3	460	30	▲	108.71 (2761)	35.56 (903)	73.15 (1858)	5.63 (143)	5.60 (142)	221.4
85S300-27	1071	3	230	30	▲	111.11 (2822)	35.56 (903)	75.56 (1919)	5.63 (143)	5.60 (142)	234.9
		3	460	30	▲	111.11 (2822)	35.56 (903)	75.56 (1919)	5.63 (143)	5.60 (142)	234.9
85S400-28	1111	3	460	40	▲	118.19 (3002)	40.28 (1023)	77.92 (1979)	5.63 (143)	5.60 (142)	246.6
85S400-29	1151	3	460	40	▲	120.6 (3063)	40.28 (1023)	80.32 (2040)	5.63 (143)	5.60 (142)	248.4
85S400-30	1191	3	460	40	▲	122.96 (3123)	40.28 (1023)	82.68 (2100)	5.63 (143)	5.60 (142)	270.0
85S400-33DS	1310	3	460	40	▲	139.22 (3536)	40.28 (1023)	98.94 (2513)	5.63 (143)	6.90 (176)	515.5
85S400-36DS	1430	3	460	40	▲	146.34 (3717)	40.28 (1023)	106.07 (2694)	5.63 (143)	6.90 (176)	454.8
85S500-39DS	1510	3	460	50	▲	169.26 (4299)	56.03 (1423)	113.23 (2876)	5.63 (143)	6.90 (176)	469.0
85S - Motor dia. 8 inch, 3 wire motor, 60 Hz, rated flow 85 gpm (3" NPT)											
85S400-33DS	1310	3	460	40	★	140.87 (3578)	43.71 (1110)	97.17 (2468)	7.56 (192)	7.56 (192)	652.7
85S400-36DS	1310	3	460	40	★	147.96 (3758)	43.71 (1110)	104.26 (2648)	7.56 (192)	7.56 (192)	592.0
85S400-39DS	1510	3	460	50	★	155.04 (3938)	43.71 (1110)	111.34 (2828)	7.56 (192)	7.56 (192)	537.2

85S

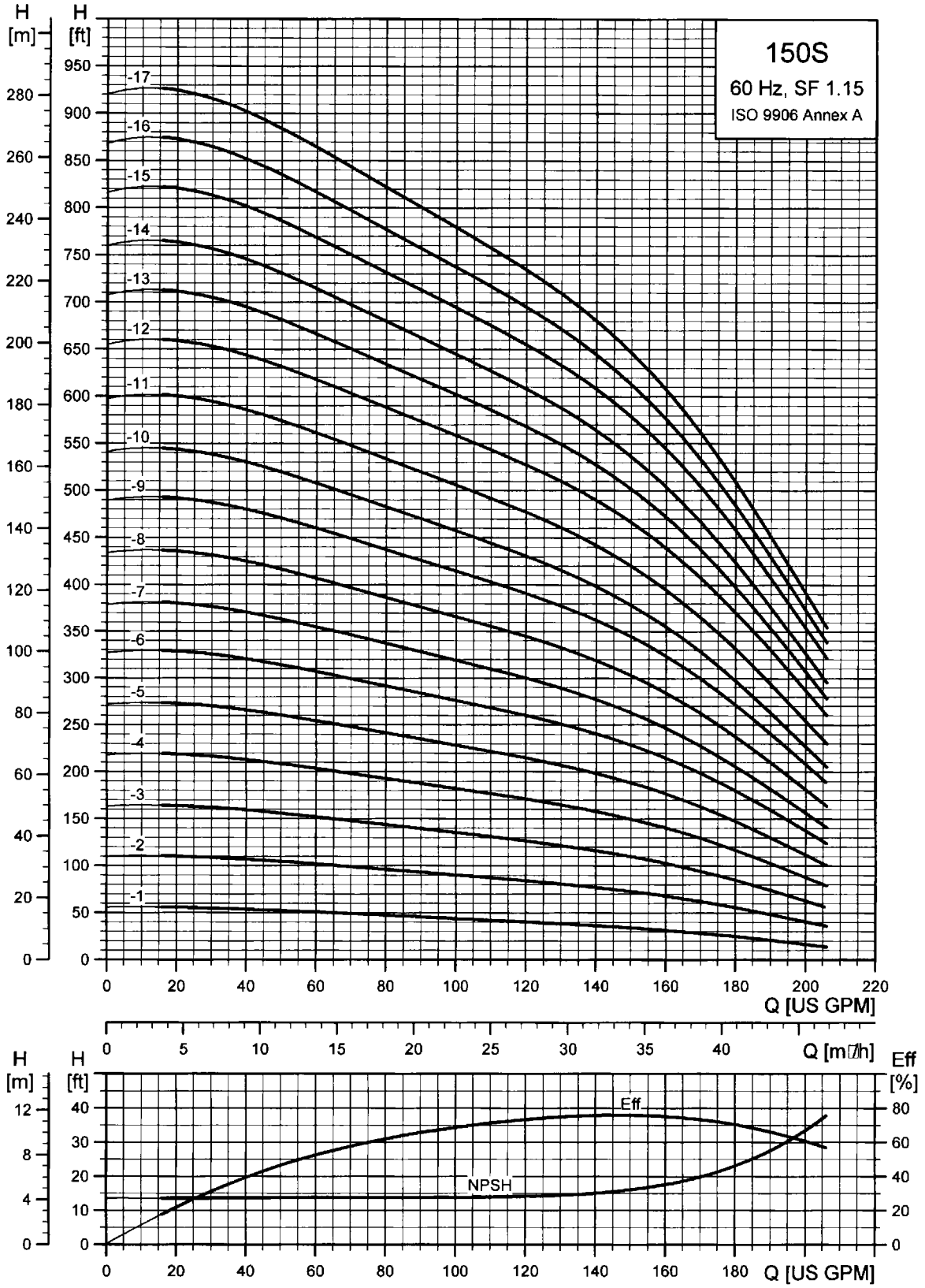


E = Maximum diameter of pump including cable guard and motor.

Notes:
Control box is required for 3-wire, single-phase applications. Data does not include control box.
DS designation = Built into sleeve, 3" NPT, 8" minimum well diameter.

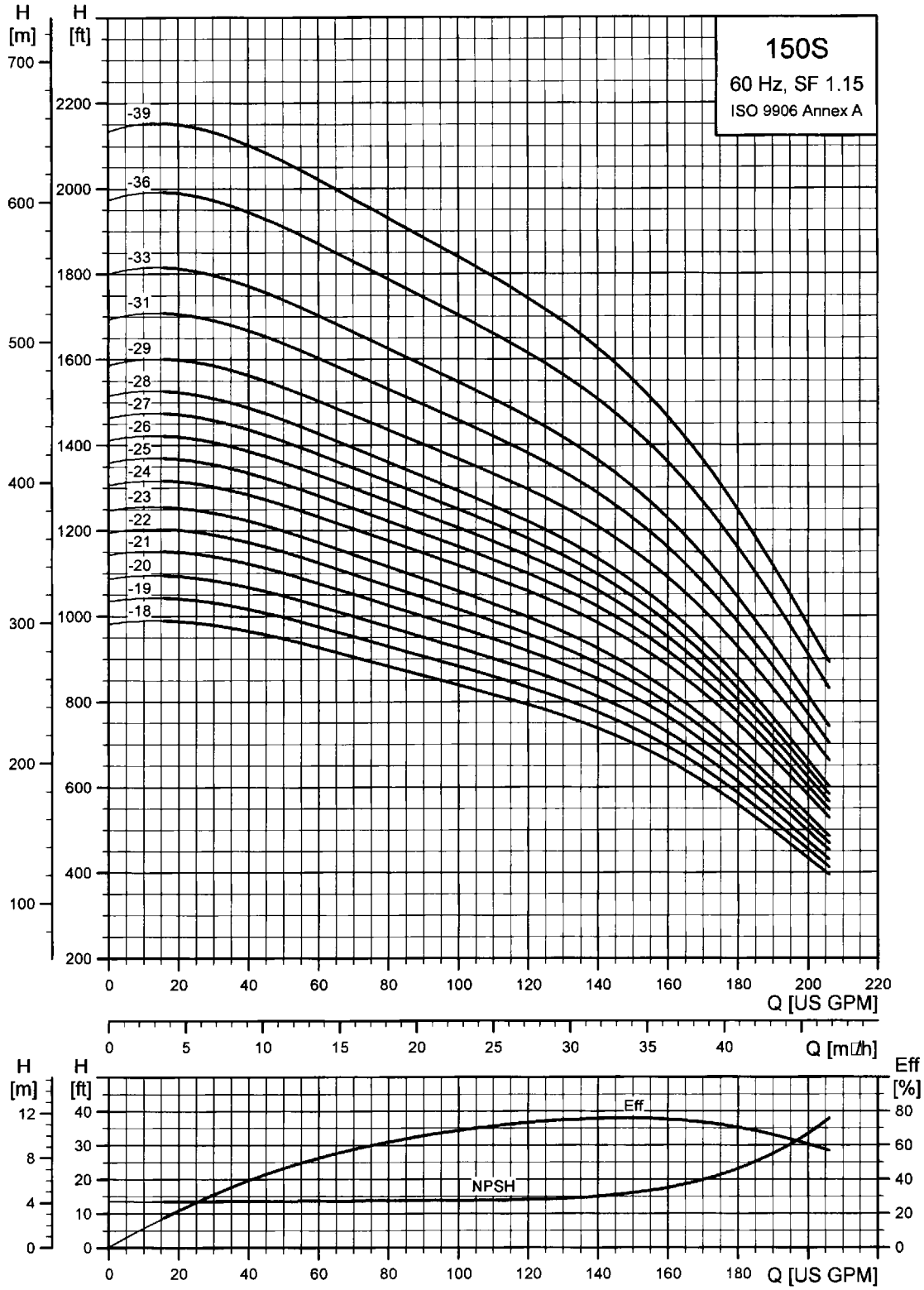
■ MS402 motor.
● MS4000 motor.
▲ MS6 motor.
∧ MMS6000 motor.
★ MMS8000 motor.
♦ Takes MS6 motor; not available as complete.
☼ Takes MMS6000 motor; not available as complete.
* Takes MMS8000 motor; not available as complete.
† Takes MMS10000 motor; not available as complete.

150S (150 gpm)

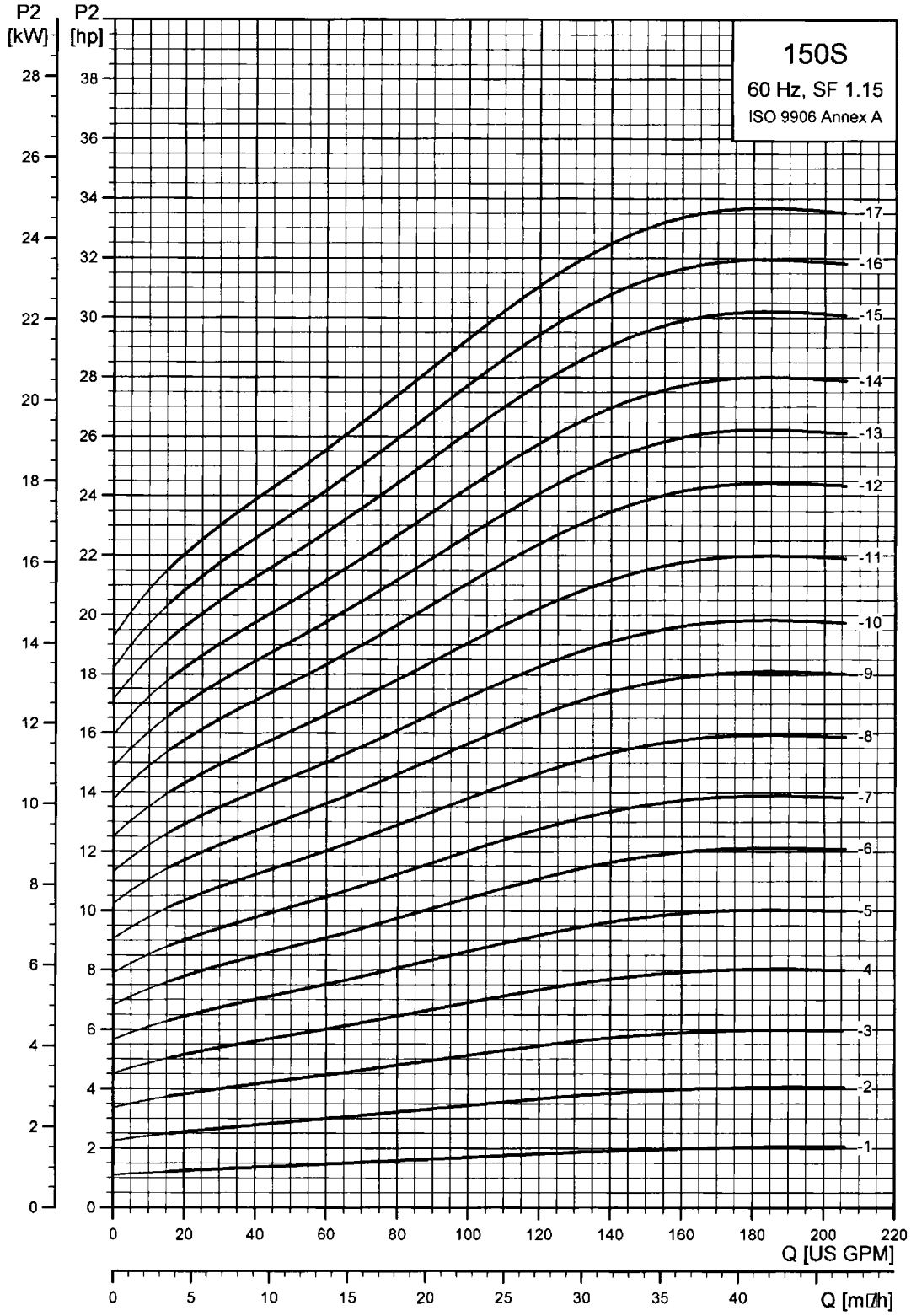


TM05 0239 0112

150S (150 gpm)

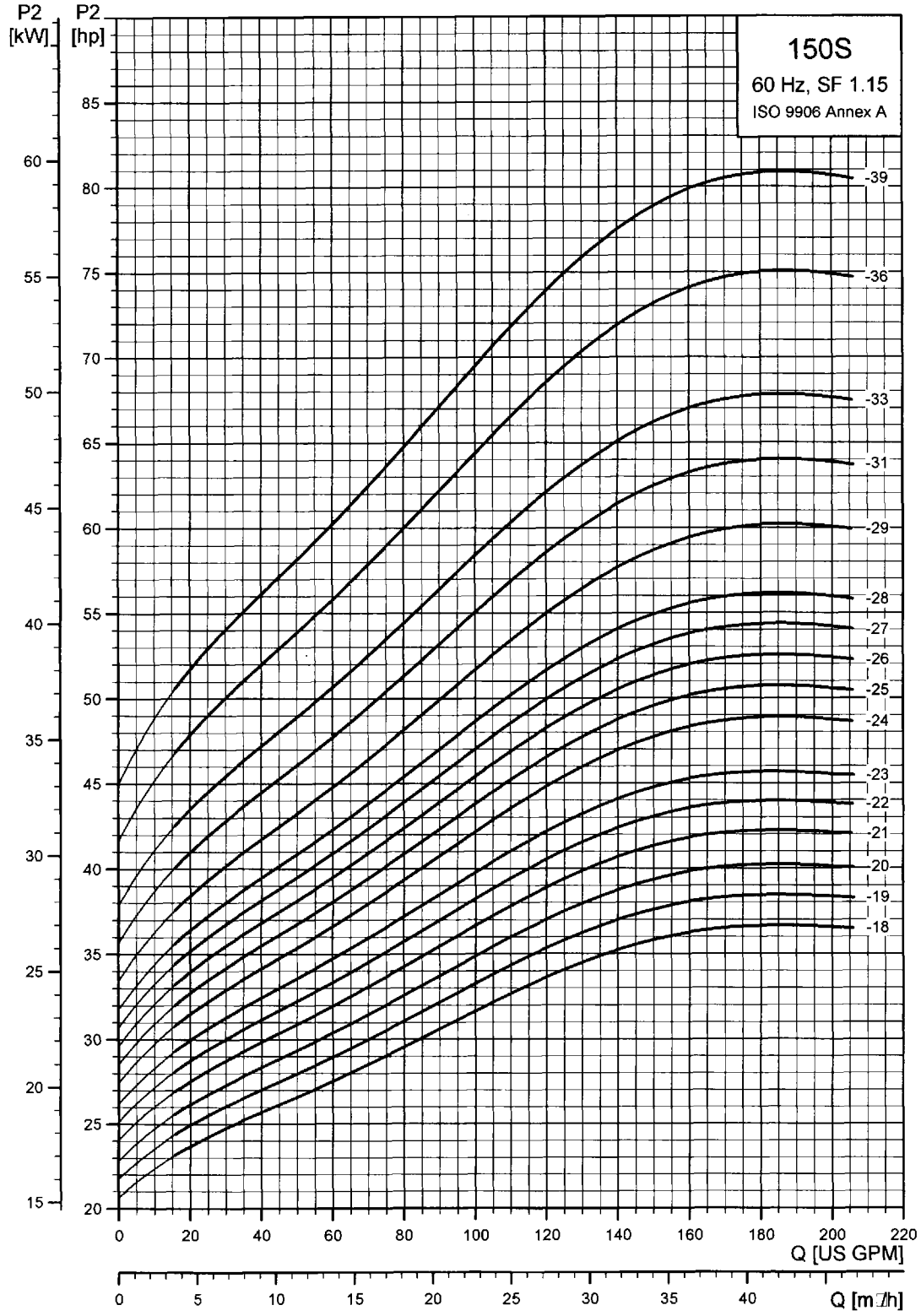

150S
60 Hz, SF 1.15
ISO 9906 Annex A
H [m]
H [ft]
-39
-36
-33
-31
-29
-28
-27
-26
-25
-24
-23
-22
-21
-20
-19
-18
Q [US GPM]
Q [m³/h]
Eff [%]
Eff
NPSH
TM05 0240 0112

150S (150 gpm) pump power requirement (P2)



TM05 0241 0112

150S (150 gpm) pump power requirement (P2)

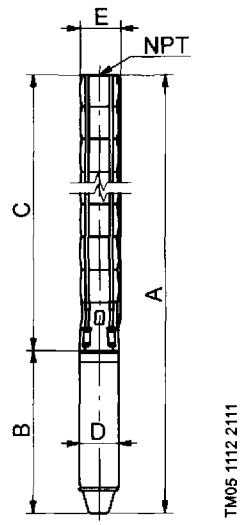


TM05 0242 0112

150S (150 gpm)

Pump model	Nom. head [ft]	Ph	Volts [V]	Motor [Hp]		Dimensions A [in (mm)]	B [in (mm)]	C [in (mm)]	D [in (mm)]	E [in (mm)]	Net weight (complete) [lb]
150S - Motor dia. 4 inch, 3 wire motor, 60 Hz, rated flow 150 gpm (3" NPT)											
150S20-1	33	1	230	2	•	33.30 (846)	19.57 (497)	13.75 (349)	3.75 (95)	5.16 (131)	49.5
		3	230	2	■	28.98 (736)	15.23 (387)	13.75 (349)	3.75 (95)	5.16 (131)	45.0
		3	460	2	■	28.98 (736)	15.23 (387)	13.75 (349)	3.75 (95)	5.16 (131)	45.0
150S50-2	71	1	230	5	•	44.17 (1122)	26.65 (677)	17.52 (445)	3.75 (95)	5.16 (131)	67.5
		3	230	5	•	40.20 (1021)	22.69 (576)	17.52 (445)	3.75 (95)	5.16 (131)	42.3
		3	460	5	•	40.20 (1021)	22.69 (576)	17.52 (445)	3.75 (95)	5.16 (131)	42.3
150S75-3	108	3	230	7.5	•	47.91 (1217)	26.63 (676)	21.3 (541)	3.75 (95)	5.16 (131)	51.3
		3	460	7.5	•	47.91 (1217)	26.63 (676)	21.3 (541)	3.75 (95)	5.16 (131)	82.8
150S75-4	146	3	230	7.5	•	51.71 (1313)	26.63 (676)	25.08 (637)	3.75 (95)	5.16 (131)	85.5
		3	460	7.5	•	51.71 (1313)	26.63 (676)	25.08 (637)	3.75 (95)	5.16 (131)	85.5
150S100-5	184	3	460	10	•	59.42 (1509)	30.56 (776)	28.86 (733)	3.75 (95)	5.16 (131)	135.9
150S - Motor dia. 6 inch, 3 wire motor, 60 Hz, rated flow 150 gpm (3" NPT)											
150S75-4	146	3	230	7.5	▲	47.96 (1218)	22.25 (565)	25.71 (653)	5.63 (143)	5.60 (142)	99.9
		3	460	7.5	▲	47.96 (1218)	22.25 (565)	25.71 (653)	5.63 (143)	5.60 (142)	99.9
150S100-5	184	3	230	10	▲	52.72 (1339)	23.23 (590)	29.49 (749)	5.63 (143)	5.60 (142)	73.8
		3	460	10	▲	52.72 (1339)	23.23 (590)	29.49 (749)	5.63 (143)	5.60 (142)	73.8
150S150-6	222	3	230	15	▲	61.15 (1553)	27.88 (708)	33.27 (845)	5.63 (143)	5.60 (142)	119.7
		3	460	15	▲	61.15 (1553)	27.88 (708)	33.27 (845)	5.63 (143)	5.60 (142)	119.7
150S150-7	260	3	230	15	▲	64.93 (1649)	27.88 (708)	37.05 (941)	5.63 (143)	5.60 (142)	127.8
		3	460	15	▲	64.93 (1649)	27.88 (708)	37.05 (941)	5.63 (143)	5.60 (142)	127.8
150S150-8	297	3	230	15	▲	68.71 (1745)	27.88 (708)	40.83 (1037)	5.63 (143)	5.60 (142)	137.7
		3	460	15	▲	68.71 (1745)	27.88 (708)	40.83 (1037)	5.63 (143)	5.60 (142)	137.7
150S200-9	335	3	230	20	▲	75.44 (1916)	30.83 (783)	44.61 (1133)	5.63 (143)	5.60 (142)	141.3
		3	460	20	▲	75.44 (1916)	30.83 (783)	44.61 (1133)	5.63 (143)	5.60 (142)	141.3
150S200-10	373	3	230	20	▲	79.22 (2012)	30.83 (783)	48.39 (1229)	5.63 (143)	5.60 (142)	151.2
		3	460	20	▲	79.22 (2012)	30.83 (783)	48.39 (1229)	5.63 (143)	5.60 (142)	151.2
150S200-11	411	3	230	20	▲	83.00 (2108)	30.83 (783)	52.17 (1325)	5.63 (143)	5.60 (142)	166.5
		3	460	20	▲	83.00 (2108)	30.83 (783)	52.17 (1325)	5.63 (143)	5.60 (142)	166.5
150S250-12	448	3	230	25	▲	88.86 (2257)	32.92 (836)	55.95 (1421)	5.63 (143)	5.60 (142)	188.1
		3	460	25	▲	88.86 (2257)	32.92 (836)	55.95 (1421)	5.63 (143)	5.60 (142)	188.1
150S250-13	486	3	230	25	▲	92.64 (2353)	32.92 (836)	59.73 (1517)	5.63 (143)	5.60 (142)	201.6
		3	460	25	▲	92.64 (2353)	32.92 (836)	59.73 (1517)	5.63 (143)	5.60 (142)	201.6
150S250-14	524	3	230	25	▲	96.42 (2449)	32.92 (836)	63.51 (1613)	5.63 (143)	5.60 (142)	206.1
		3	460	25	▲	96.42 (2449)	32.92 (836)	63.51 (1613)	5.63 (143)	5.60 (142)	206.1

150S



E = Maximum diameter of pump including cable guard and motor.

Notes:
Control box is required for 3-wire, single-phase applications. Data does not include control box.
■ MS402 motor.
• MS4000 motor.
▲ MS6 motor.
∧ MMS6000 motor.
★ MMS8000 motor.
♦ Takes MS6 motor; not available as complete.
☼ Takes MMS6000 motor; not available as complete.
* Takes MMS8000 motor; not available as complete.
† Takes MMS10000 motor; not available as complete.

150S (150 gpm)

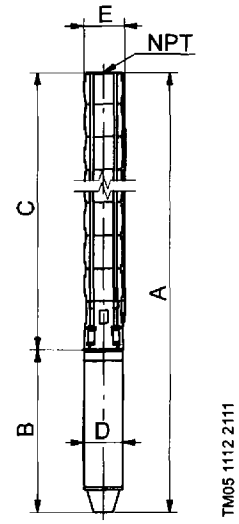
Pump model	Nom. head [ft]	Ph	Volts [V]	Motor [Hp]		Dimensions A [in (mm)]	B [in (mm)]	C [in (mm)]	D [in (mm)]	E [in (mm)]	Net weight (complete) [lb]
150S - Motor dia. 6 inch, 3 wire motor, 60 Hz, rated flow 150 gpm (3" NPT)											
150S300-15	562	3	230	30	▲	102.84 (2612)	35.56 (903)	67.29 (1709)	5.63 (143)	5.60 (142)	209.7
		3	460	30	▲	102.84 (2612)	35.56 (903)	67.29 (1709)	5.63 (143)	5.60 (142)	209.7
150S300-16	600	3	230	30	▲	106.62 (2708)	35.56 (903)	71.07 (1805)	5.63 (143)	5.60 (142)	211.5
		3	460	30	▲	106.62 (2708)	35.56 (903)	71.07 (1805)	5.63 (143)	5.60 (142)	211.5
150S300-17	637	3	230	30	▲	110.4 (2804)	35.56 (903)	74.85 (1901)	5.63 (143)	5.60 (142)	216.0
		3	460	30	▲	110.4 (2804)	35.56 (903)	74.85 (1901)	5.63 (143)	5.60 (142)	246.6
150S400-18	675	3	460	40	▲	118.9 (3020)	40.28 (1023)	78.63 (1997)	5.63 (143)	5.60 (142)	246.6
150S400-19	713	3	460	40	▲	122.68 (3116)	40.28 (1023)	82.41 (2093)	5.63 (143)	5.60 (142)	248.4
150S400-20	751	3	460	40	▲	126.46 (3212)	40.28 (1023)	86.19 (2189)	5.63 (143)	5.60 (142)	291.0
150S400-21	789	3	460	40	▲	130.24 (3308)	40.28 (1023)	89.97 (2285)	5.63 (143)	5.67 (144)	271.8
150S400-22	826	3	460	40	▲	134.02 (3404)	40.28 (1023)	93.75 (2381)	5.63 (143)	5.67 (144)	305.9
150S400-23	864	3	460	40	▲	137.8 (3500)	40.28 (1023)	97.52 (2477)	5.63 (143)	5.67 (144)	277.2
150S500-24	902	3	460	50	☼	157.41 (3998)	56.11 (1425)	101.3 (2573)	5.67 (144)	5.60 (142)	411.8
150S500-25	940	3	460	50	☼	161.19 (4094)	56.11 (1425)	105.08 (2669)	5.67 (144)	5.60 (142)	419.0
150S500-26	977	3	460	50	☼	164.97 (4190)	56.11 (1425)	108.86 (2765)	5.67 (144)	5.60 (142)	426.2
150S500-27	1015	3	460	50	☼	168.75 (4286)	56.11 (1425)	112.64 (2861)	5.67 (144)	5.60 (142)	433.4
150S500-28	1053	3	460	50	☼	172.52 (4382)	56.11 (1425)	116.42 (2957)	5.67 (144)	5.60 (142)	440.6
150S600-29DS	1091	3	460	60	-	—	—	129.05 (3278)	—	7.10 (181)	—
150S600-31DS	1166	3	460	60	-	—	—	136.61 (3470)	—	7.10 (181)	—
150S600-33DS	1242	3	460	60	-	—	—	144.17 (3662)	—	7.10 (181)	—

150S - Motor dia. 8 inch, 3 wire motor, 60 Hz, rated flow 150 gpm (3" NPT)											
150S500-24	902	3	460	50	*	148.12 (3762)	45.67 (1160)	102.45 (2602)	7.56 (192)	7.56 (192)	484.5
150S500-25	940	3	460	50	*	151.89 (3858)	45.67 (1160)	106.23 (2698)	7.56 (192)	7.56 (192)	491.7
150S500-26	977	3	460	50	*	155.67 (3954)	45.67 (1160)	110.00 (2794)	7.56 (192)	7.56 (192)	498.9
150S500-27	1015	3	460	50	*	159.45 (4050)	45.67 (1160)	113.78 (2890)	7.56 (192)	7.56 (192)	506.1
150S500-28	1053	3	460	50	*	163.23 (4146)	45.67 (1160)	117.56 (2986)	7.56 (192)	7.56 (192)	513.3
150S600-29DS	1091	3	460	60	*	177.92 (4519)	50.00 (1270)	127.92 (3249)	7.56 (192)	7.56 (192)	612.7
150S600-31DS	1166	3	460	60	*	185.48 (4711)	50.00 (1270)	135.48 (3441)	7.56 (192)	7.56 (192)	623.7
150S600-33DS	1242	3	460	60	*	193.04 (4903)	50.00 (1270)	143.04 (3633)	7.56 (192)	7.56 (192)	639.1
150S750-36DS	1355	3	460	75	*	207.52 (5271)	53.15 (1350)	154.38 (3921)	7.56 (192)	7.56 (192)	689.2
150S750-39DS	1469	3	460	75	*	218.86 (5559)	53.15 (1350)	165.71 (4209)	7.56 (192)	7.56 (192)	704.6

Notes:
Control box is required for 3-wire, single-phase applications. Data does not include control box.
DS designation = Built into sleeve, 3" NPT, 8" minimum well diameter.

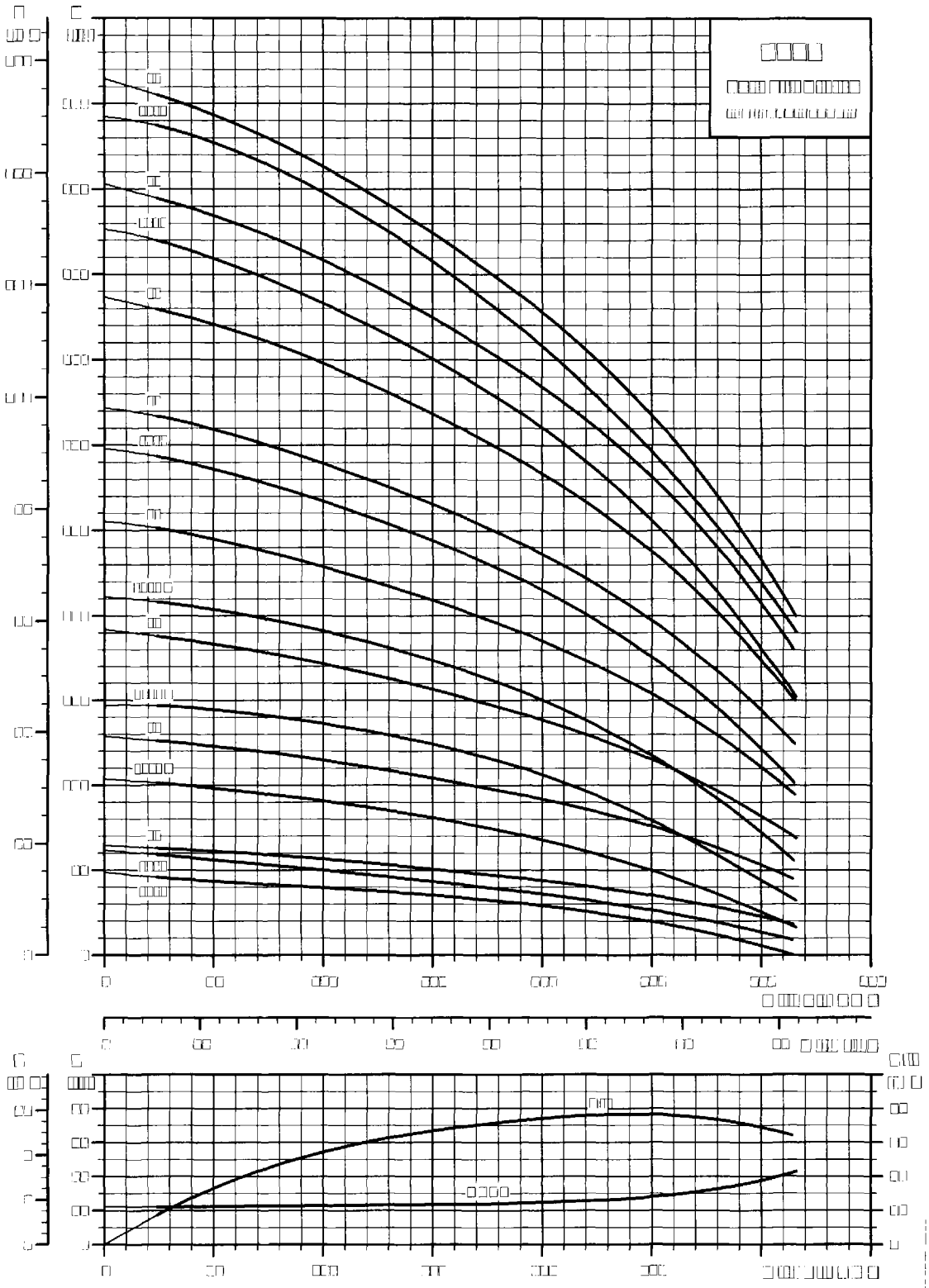
- ■ MS402 motor.
- • MS4000 motor.
- ▲ MS6 motor.
- ∧ MMS6000 motor.
- ★ MMS8000 motor.
- ♦ Takes MS6 motor; not available as complete.
- ☼ Takes MMS6000 motor; not available as complete.
- * Takes MMS8000 motor; not available as complete.
- † Takes MMS10000 motor; not available as complete.

150S



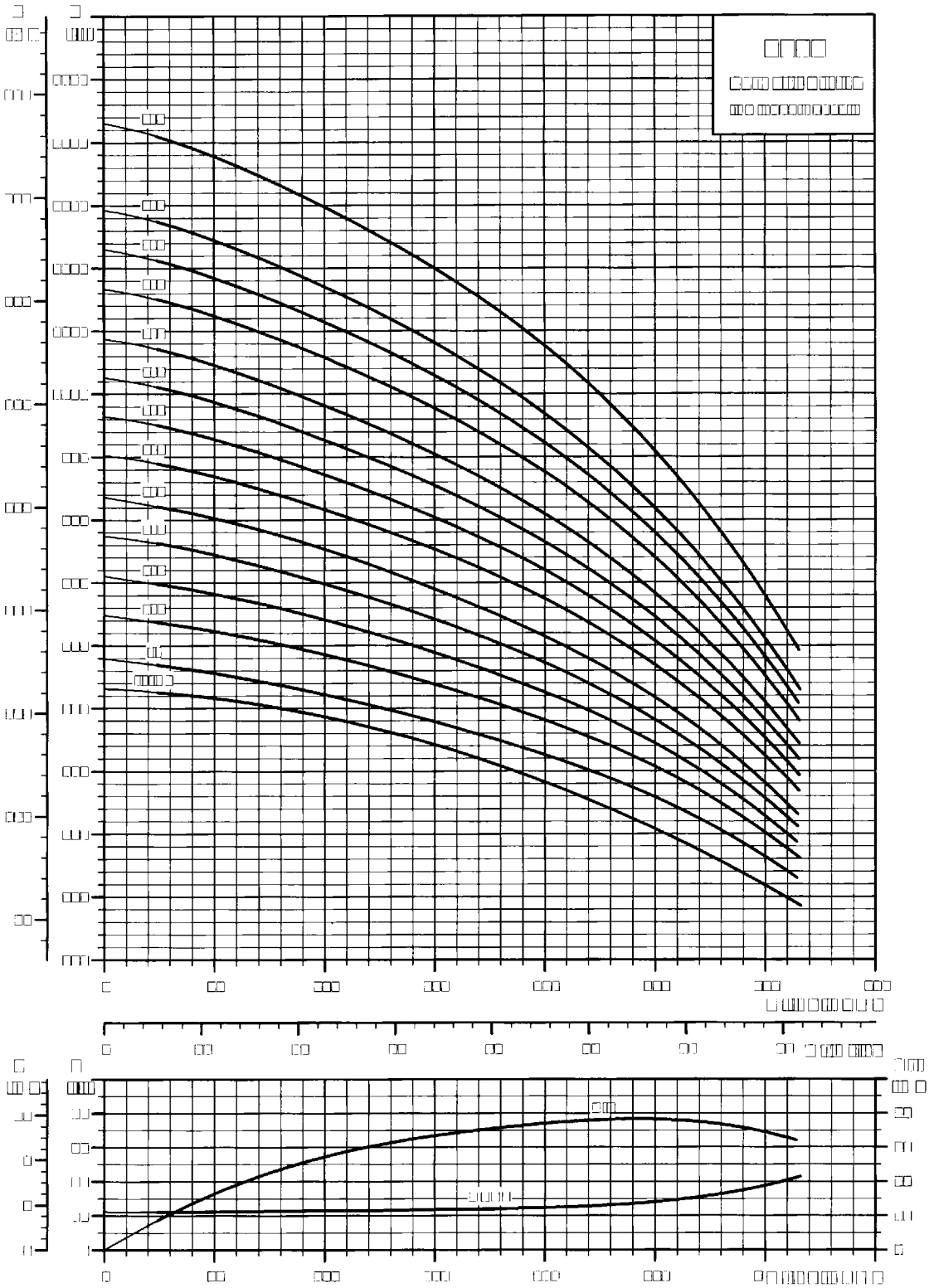
E = Maximum diameter of pump including cable guard and motor.

230S (230 gpm)



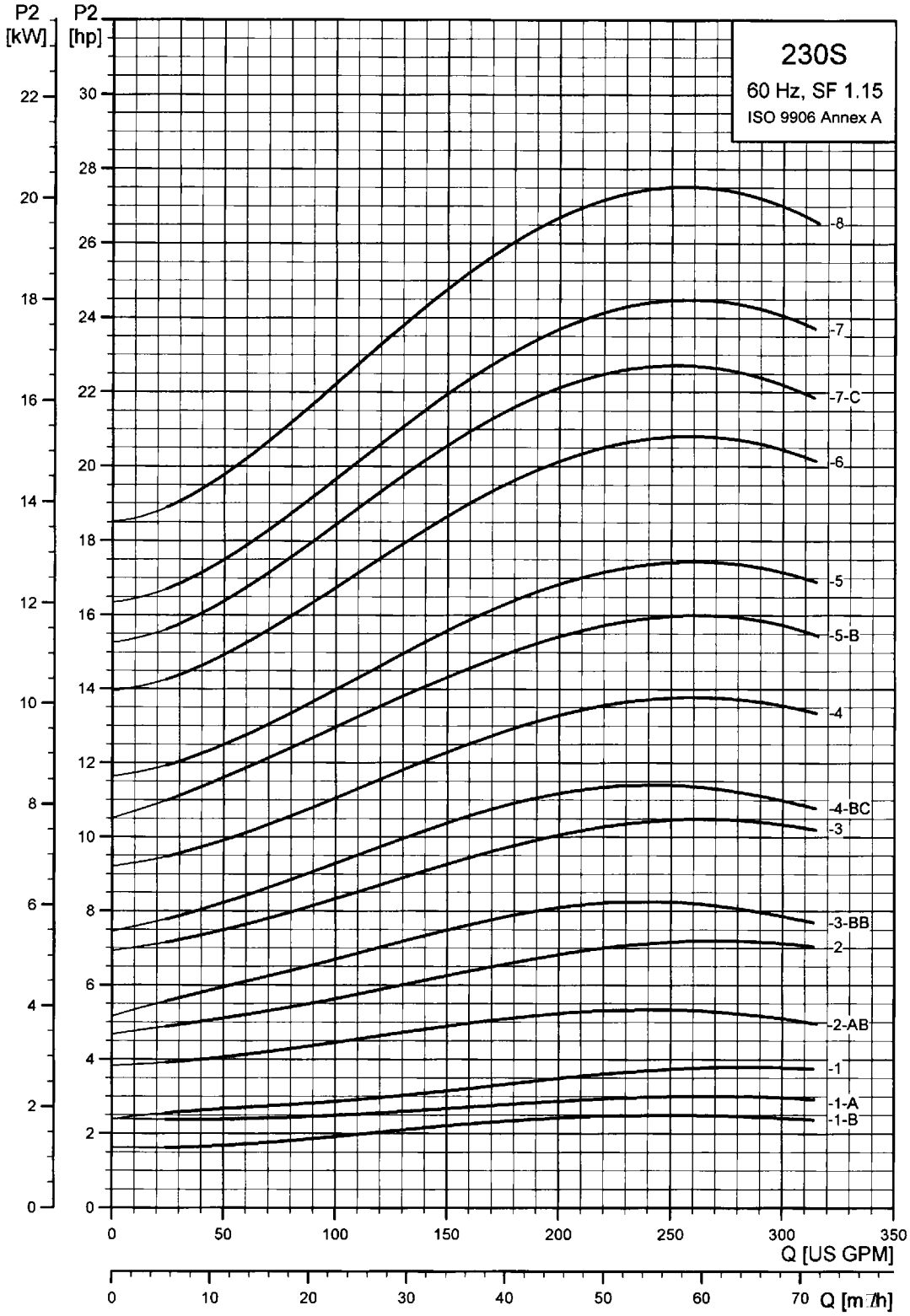
TM05 0243 0312

230S (230 gpm)



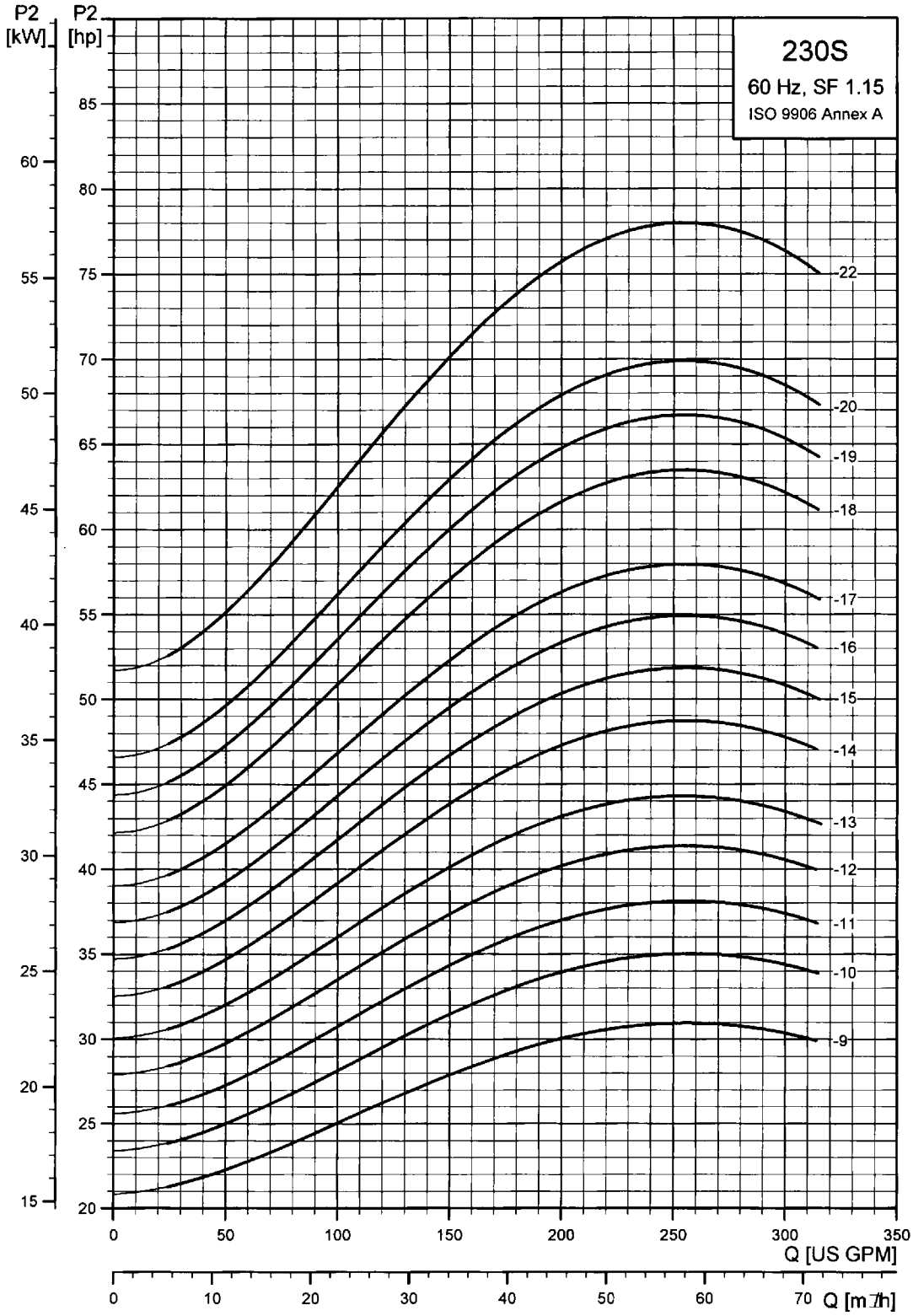
TM05 0244 0312

230S (230 gpm) pump power requirement (P2)



TM05 0245 0112

230S (230 gpm) pump power requirement (P2)

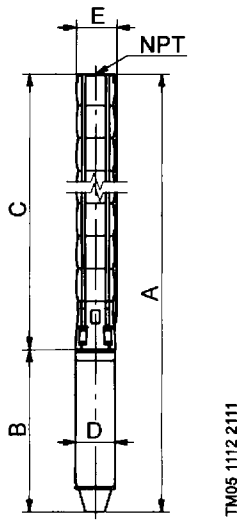


TM05 0246 0112

230S (230 gpm)

Pump model	Nom. head [ft]	Ph	Volts [V]	Motor [Hp]		Dimensions A [in (mm)]	B [in (mm)]	C [in (mm)]	D [in (mm)]	E [in (mm)]	Net weight (complete) [lb]
230S - Motor dia. 4 inch, 3 wire motor, 60 Hz, rated flow 230 gpm (3" NPT)											
230S20-1B	24	1	230	2	•	33.90 (861)	19.57 (497)	14.34 (364)	3.75 (95)	5.75 (146)	49.5
		3	230	2	•	25.67 (751)	15.24 (387)	14.34 (364)	3.75 (95)	5.75 (146)	49.5
		3	460	2	■	25.67 (751)	15.24 (387)	14.34 (364)	3.75 (95)	5.75 (146)	49.5
230S30-1A	30	1	230	3	•	37.05 (941)	22.72 (577)	14.34 (364)	3.75 (95)	5.75 (146)	49.5
		3	230	3	•	46.65 (1185)	17.96 (456)	14.34 (364)	3.75 (95)	5.75 (146)	49.5
		3	460	3	•	46.65 (1185)	17.96 (456)	14.34 (364)	3.75 (95)	5.75 (146)	49.5
230S50-1	37	1	230	5	•	40.98 (1041)	26.65 (677)	14.34 (364)	3.75 (95)	5.75 (146)	49.5
		3	230	5	•	37.01 (940)	22.69 (576)	14.34 (364)	3.75 (95)	5.75 (146)	49.5
		3	460	5	•	37.01 (940)	22.69 (576)	14.34 (364)	3.75 (95)	5.75 (146)	49.5
230S50-2AB	56	1	230	5	•	45.43 (1154)	26.65 (677)	18.78 (477)	3.75 (95)	5.75 (146)	49.5
		3	230	5	•	41.46 (1053)	22.69 (576)	18.78 (477)	3.75 (95)	5.75 (146)	79.2
		3	460	5	•	41.46 (1053)	22.69 (576)	18.78 (477)	3.75 (95)	5.75 (146)	79.2
230S75-2	80	3	230	7.5	•	45.39 (1153)	26.63 (676)	23.23 (590)	3.75 (95)	5.75 (146)	79.2
		3	460	7.5	•	45.39 (1153)	26.63 (676)	23.23 (590)	3.75 (95)	5.75 (146)	79.2
230S75-3BB	90	3	230	7.5	•	49.84 (1266)	26.63 (676)	23.23 (590)	3.75 (95)	5.75 (146)	126.0
		3	460	7.5	•	49.84 (1266)	26.63 (676)	23.23 (590)	3.75 (95)	5.75 (146)	126.0
230S100-3	123	3	460	10	•	53.78 (1366)	30.56 (776)	23.23 (590)	3.75 (95)	5.75 (146)	126.0
230S100-4BC	131	3	460	10	•	53.78 (1366)	30.56 (776)	23.23 (590)	3.75 (95)	5.75 (146)	144.9
230S - Motor dia. 6 inch, 3 wire motor, 60 Hz, rated flow 230 gpm (3" NPT)											
230S75-2	80	3	230	7.5	▲	41.65 (1058)	22.25 (565)	19.41 (493)	5.63 (143)	5.99 (152)	111.6
		3	460	7.5	▲	41.65 (1058)	22.25 (565)	19.41 (493)	5.63 (143)	5.99 (152)	111.6
230S75-3BB	90	3	230	7.5	▲	46.10 (1171)	22.25 (565)	23.86 (606)	5.63 (143)	5.99 (152)	131.4
		3	460	7.5	▲	46.10 (1171)	22.25 (565)	23.86 (606)	5.63 (143)	5.99 (152)	131.4
230S100-3	123	3	230	10	▲	47.09 (1196)	23.23 (590)	23.86 (606)	5.63 (143)	5.99 (152)	126.0
		3	460	10	▲	47.09 (1196)	23.23 (590)	23.86 (606)	5.63 (143)	5.99 (152)	126.0
230S100-4BC	131	3	230	10	▲	51.54 (1309)	23.23 (590)	28.31 (719)	5.63 (143)	5.99 (152)	144.9
		3	460	10	▲	51.54 (1309)	23.23 (590)	28.31 (719)	5.63 (143)	5.99 (152)	144.9
230S150-4	166	3	230	15	▲	56.19 (1427)	27.88 (708)	28.31 (719)	5.63 (143)	5.99 (152)	144.9
		3	460	15	▲	56.19 (1427)	27.88 (708)	28.31 (719)	5.63 (143)	5.99 (152)	144.9
230S150-5B	195	3	230	15	▲	60.63 (1540)	27.88 (708)	32.76 (832)	5.63 (143)	5.99 (152)	161.1
		3	460	15	▲	60.63 (1540)	27.88 (708)	32.76 (832)	5.63 (143)	5.99 (152)	161.1
230S200-5	208	3	230	20	▲	63.59 (1615)	30.83 (783)	32.76 (832)	5.63 (143)	5.99 (152)	161.1
		3	460	20	▲	63.59 (1615)	30.83 (783)	32.76 (832)	5.63 (143)	5.99 (152)	161.1
230S200-6	251	3	230	20	▲	68.04 (1728)	30.83 (783)	37.21 (945)	5.63 (143)	5.99 (152)	167.4
		3	460	20	▲	68.04 (1728)	30.83 (783)	37.21 (945)	5.63 (143)	5.99 (152)	167.4
230S200-7C	276	3	230	20	▲	72.49 (1841)	30.83 (783)	41.66 (1058)	5.63 (143)	5.99 (152)	181.8
		3	460	20	▲	72.49 (1841)	30.83 (783)	41.66 (1058)	5.63 (143)	5.99 (152)	181.8

230S



E = Maximum diameter of pump including cable guard and motor.

Notes:
Control box is required for 3-wire, single-phase applications. Data does not include control box.
■ MS402 motor.
• MS4000 motor.
▲ MS6 motor.
∧ MMS6000 motor.
★ MMS8000 motor.
♦ Takes MS6 motor; not available as complete.
☼ Takes MMS6000 motor; not available as complete.
* Takes MMS8000 motor; not available as complete.
† Takes MMS10000 motor; not available as complete.

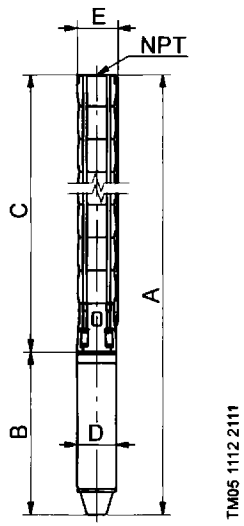
230S (230 gpm)

Pump model	Nom. head [ft]	Ph	Volts [V]	Motor [Hp]		Dimensions A [in (mm)]	B [in (mm)]	C [in (mm)]	D [in (mm)]	E [in (mm)]	Net weight (complete) [lb]
230S - Motor dia. 6 inch, 3 wire motor, 60 Hz, rated flow 230 gpm (3" NPT)											
230S250-7	294	3	230	25	▲	74.65 (1896)	33.00 (838)	41.66 (1058)	5.63 (143)	5.99 (152)	149.9
		3	460	25	▲	74.65 (1896)	33.00 (838)	41.66 (1058)	5.63 (143)	5.99 (152)	181.8
230S250-8B	329	3	230	25	▲	79.10 (2009)	33.00 (838)	46.11 (1171)	5.63 (143)	5.99 (152)	188.1
		3	460	25	▲	79.10 (2009)	33.00 (838)	46.11 (1171)	5.63 (143)	5.99 (152)	188.1
230S250-8	336	3	230	25	▲	79.10 (2009)	33.00 (838)	46.11 (1171)	5.63 (143)	5.99 (152)	188.1
		3	460	25	▲	79.10 (2009)	33.00 (838)	46.11 (1171)	5.63 (143)	5.99 (152)	188.1
230S250-9BB	352	3	230	25	▲	83.55 (2122)	33.00 (838)	50.56 (1284)	5.63 (143)	5.99 (152)	205.2
		3	460	25	▲	83.55 (2122)	33.00 (838)	50.56 (1284)	5.63 (143)	5.99 (152)	205.2
230S300-9	379	3	230	30	▲	86.11 (2187)	35.56 (903)	50.56 (1284)	5.63 (143)	5.99 (152)	205.2
		3	460	30	▲	86.11 (2187)	35.56 (903)	50.56 (1284)	5.63 (143)	5.99 (152)	205.2
230S400-10	422	3	460	30	▲	95.28 (2420)	40.28 (1023)	55.00 (1397)	5.63 (143)	5.99 (152)	241.2
230S400-11	465	3	460	40	▲	99.73 (2533)	40.28 (1023)	59.45 (1510)	5.63 (143)	5.99 (152)	245.7
230S400-12	507	3	460	40	▲	104.18 (2646)	40.28 (1023)	63.9 (1623)	5.63 (143)	5.99 (152)	251.1
230S400-13	550	3	460	40	▲	108.63 (2759)	40.28 (1023)	68.35 (1736)	5.63 (143)	5.99 (152)	255.6
230S500-14	593	3	460	50	∧	132.17 (3357)	56.11 (1425)	76.07 (1932)	5.67 (144)	5.99 (152)	356.0
230S500-15	635	3	460	50	∧	136.62 (3470)	56.11 (1425)	80.52 (2045)	5.67 (144)	5.99 (152)	360.5
230S500-16	678	3	460	50	∧	141.07 (3583)	56.11 (1425)	84.97 (2158)	5.67 (144)	5.99 (152)	365.0
230S600-17	721	3	460	60	▲	—	—	88.54 (2249)	—	5.99 (152)	—
230S600-18	763	3	460	60	▲	—	—	92.99 (2362)	—	5.99 (152)	—
230S600-19	806	3	460	60	▲	—	—	97.44 (2475)	—	7.56 (192)	—
230S - Motor dia. 8 inch, 3 wire motor, 60 Hz, rated flow 230 gpm (3" NPT)											
230S600-17	721	3	460	60	★	137.41 (3490)	50.00 (1270)	87.41 (2220)	7.56 (192)	7.56 (192)	546.0
230S600-18	763	3	460	60	★	141.86 (3690)	50.00 (1270)	91.86 (2333)	7.56 (192)	7.56 (192)	568.5
230S600-19	806	3	460	60	★	146.3 (3716)	50.00 (1270)	96.3 (2446)	7.56 (192)	7.56 (192)	591.0
230S750-20DS	849	3	460	75	★	153.9 (3909)	53.15 (1350)	100.75 (2559)	7.56 (192)	7.56 (192)	549.9
230S750-22DS	934	3	460	75	★	169.22 (4298)	53.15 (1350)	116.07 (2948)	7.56 (192)	7.56 (192)	620.4

Notes:
Control box is required for 3-wire, single-phase applications. Data does not include control box.
DS designation = Built into sleeve, 4" NPT, 10" minimum well diameter.

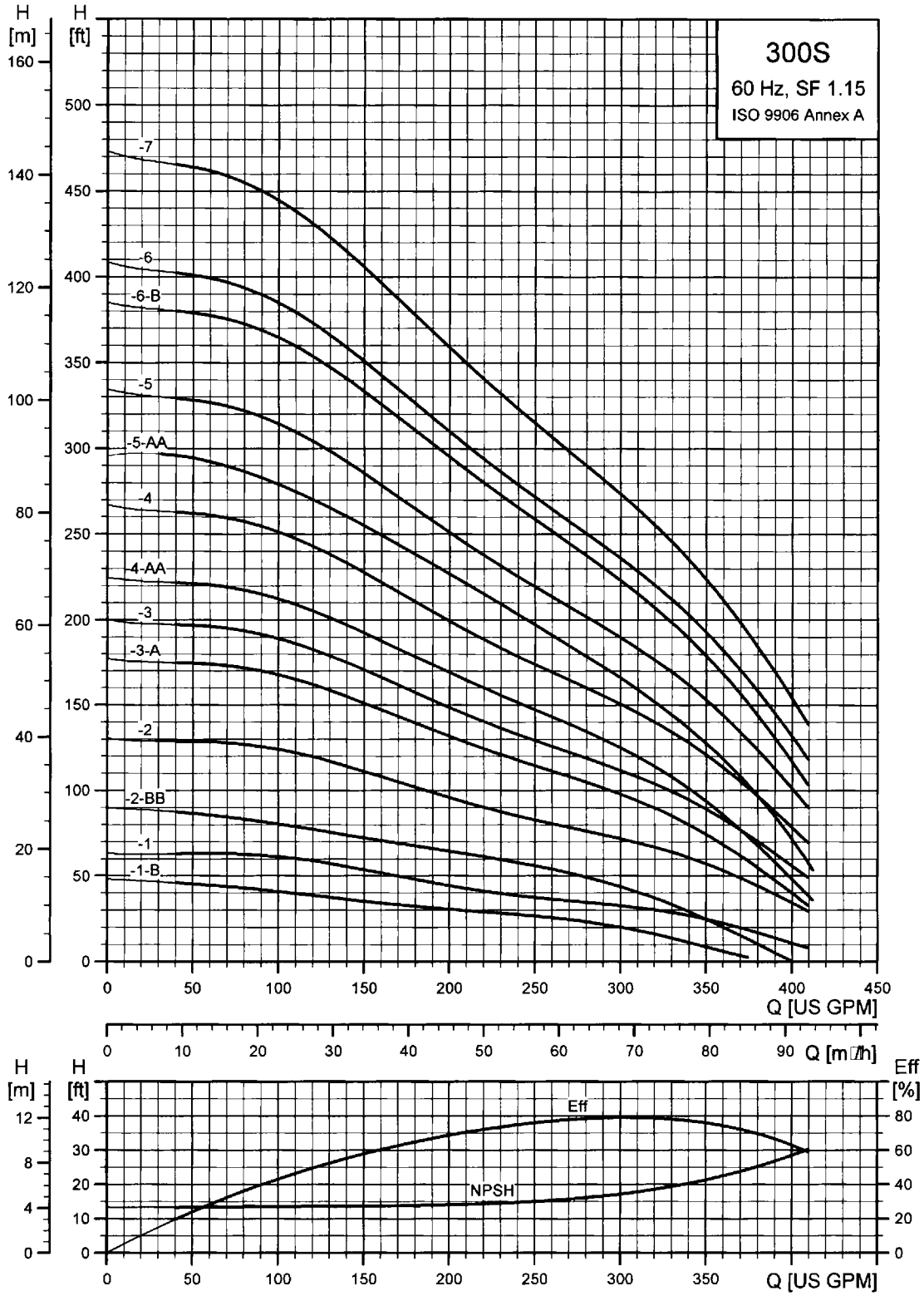
- ■ MS402 motor.
- ● MS4000 motor.
- ▲ MS6 motor.
- ∧ MMS6000 motor.
- ★ MMS8000 motor.
- ♦ Takes MS6 motor; not available as complete.
- ☼ Takes MMS6000 motor; not available as complete.
- * Takes MMS8000 motor; not available as complete.
- † Takes MMS10000 motor; not available as complete.

230S



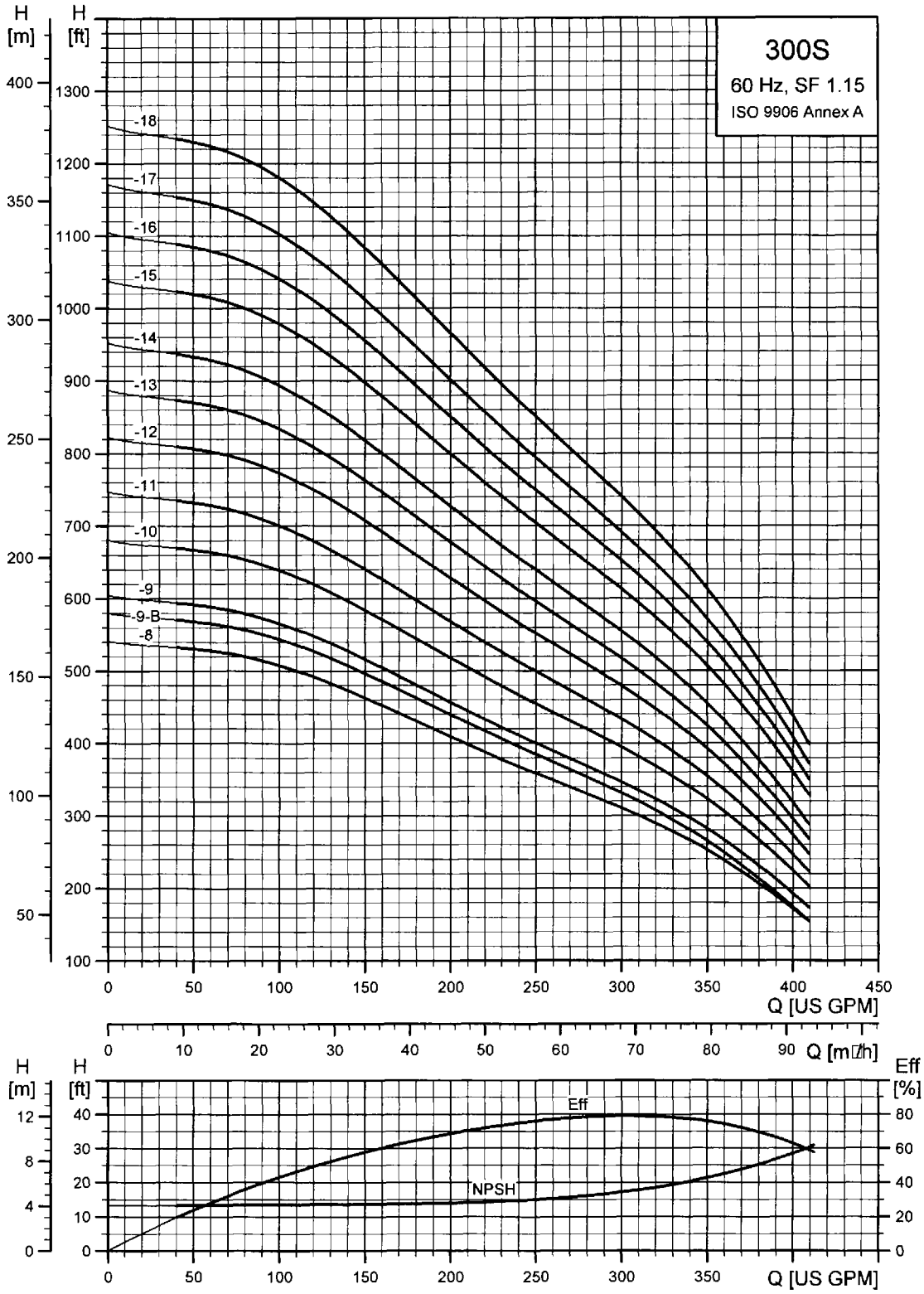
E = Maximum diameter of pump including cable guard and motor.

300S (300 gpm)



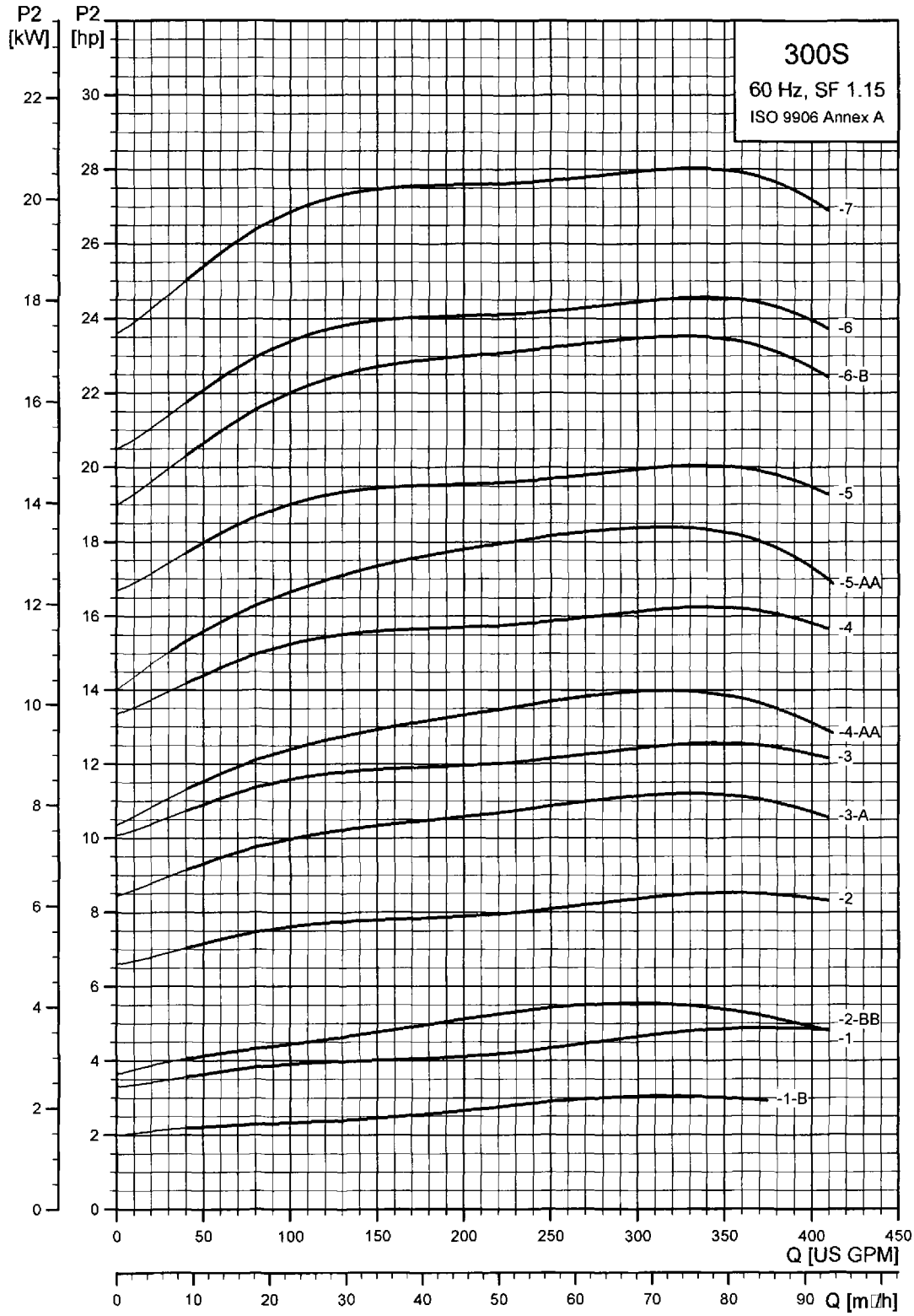
TM05 0247 0112

300S (300 gpm)



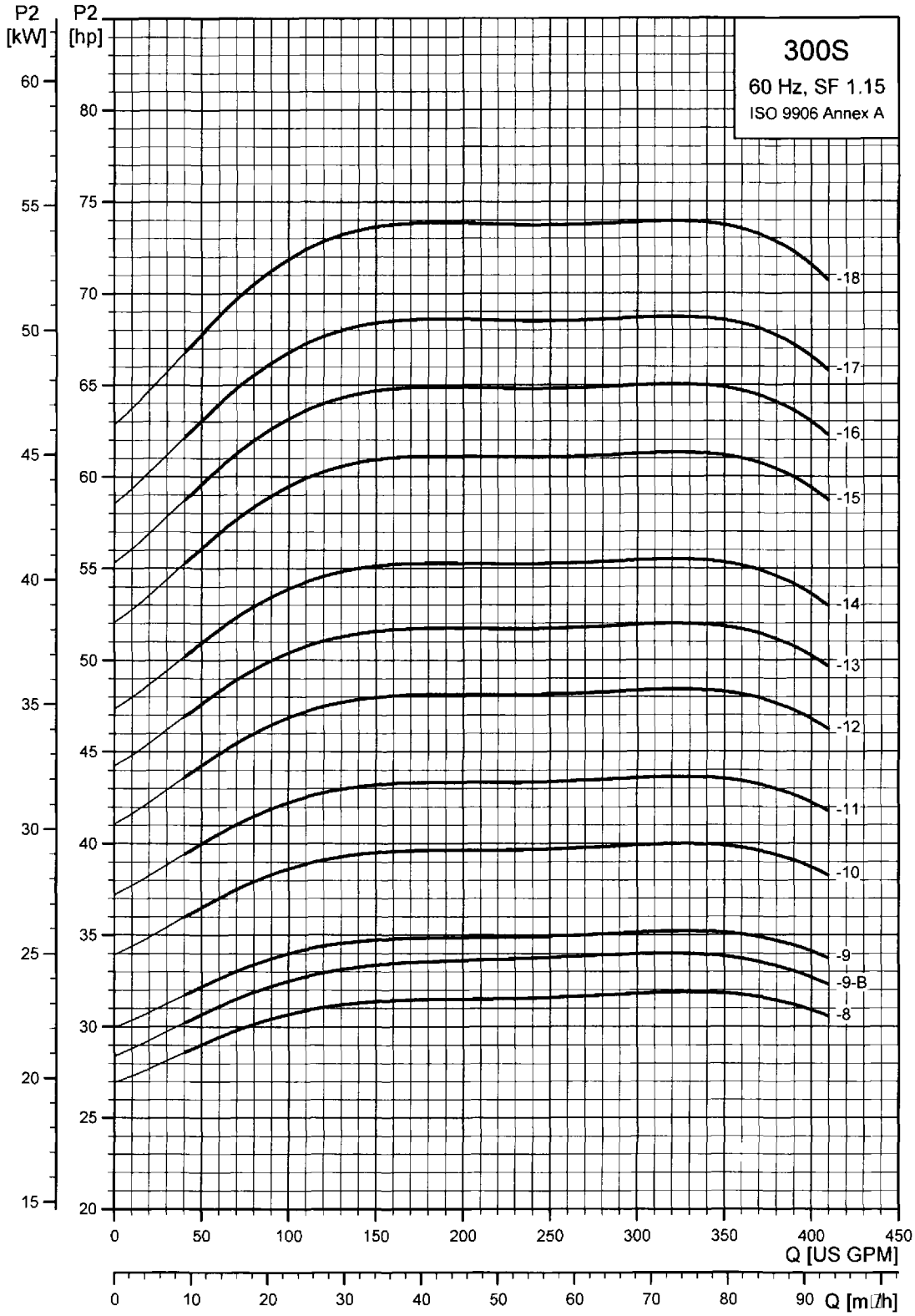
TM05 0248 0112

300S (300 gpm) pump power requirement (P2)



TM05 0249 0112

300S (300 gpm) pump power requirement (P2)

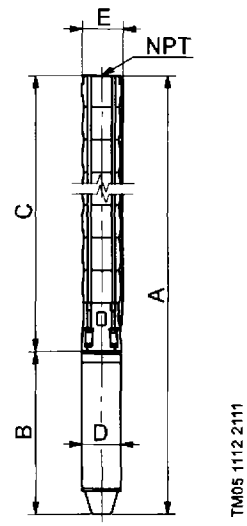


TM05 0250 0112

300S (300 gpm)

Pump model	Nom. head [ft]	Ph	Volts [V]	Motor [Hp]		Dimensions A [in (mm)]	B [in (mm)]	C [in (mm)]	D [in (mm)]	E [in (mm)]	Net weight (complete) [lb]
300S - Motor dia. 4 inch, 3 wire motor, 60 Hz, rated flow 300 gpm (3" NPT)											
300S30-1B	19	1	230	3	•	37.17 (944)	22.72 (577)	14.45 (367)	3.75 (95)	5.83 (148)	72.0
		3	230	3	•	32.41 (823)	17.96 (456)	14.45 (367)	3.75 (95)	5.83 (148)	72.0
		3	460	3	•	32.41 (823)	17.96 (456)	14.45 (367)	3.75 (95)	5.83 (148)	72.0
300S50-1	31	1	230	5	•	41.11 (1044)	26.65 (677)	14.45 (367)	3.75 (95)	5.83 (148)	74.7
		3	230	5	•	37.13 (943)	22.69 (576)	14.45 (367)	3.75 (95)	5.83 (148)	74.7
		3	460	5	•	37.13 (943)	22.69 (576)	14.45 (367)	3.75 (95)	5.83 (148)	74.7
300S50-2BB	42	1	230	5	•	45.56 (1157)	26.65 (677)	18.90 (480)	3.75 (95)	5.83 (148)	135.0
		3	230	5	•	41.58 (1056)	22.69 (576)	18.90 (480)	3.75 (95)	5.83 (148)	135.0
		3	460	5	•	41.58 (1056)	22.69 (576)	18.90 (480)	3.75 (95)	5.83 (148)	135.0
300S75-2	70	3	230	7.5	•	45.52 (1156)	26.62 (676)	18.90 (480)	3.75 (95)	5.83 (148)	101.7
		3	460	7.5	•	45.52 (1156)	26.62 (676)	18.90 (480)	3.75 (95)	5.83 (148)	101.7
300S100-3A	97	3	460	10	•	53.90 (1369)	30.56 (776)	23.35 (593)	3.75 (95)	5.83 (148)	145.8
300S - Motor dia. 6 inch, 3 wire motor, 60 Hz, rated flow 300 gpm (3" NPT)											
300S75-2	70	3	230	7.5	▲	41.78 (1061)	22.25 (565)	19.53 (496)	5.63 (143)	6.15 (156)	167.4
		3	460	7.5	▲	41.78 (1061)	22.25 (565)	19.53 (496)	5.63 (143)	6.15 (156)	167.4
300S100-3A	97	3	230	10	▲	47.21 (1199)	23.23 (590)	23.98 (609)	5.63 (143)	6.15 (156)	216.0
		3	460	10	▲	47.21 (1199)	23.23 (590)	23.98 (609)	5.63 (143)	6.15 (156)	216.0
300S150-3	110	3	230	15	▲	51.86 (1317)	27.88 (708)	23.98 (609)	5.63 (143)	6.15 (156)	216.0
		3	460	15	▲	51.86 (1317)	27.88 (708)	23.98 (609)	5.63 (143)	6.15 (156)	216.0
300S150-4AA	123	3	230	15	▲	56.30 (1430)	27.88 (708)	28.43 (722)	5.63 (143)	6.15 (156)	222.3
		3	460	15	▲	56.30 (1430)	27.88 (708)	28.43 (722)	5.63 (143)	6.15 (156)	222.3
300S150-4	149	3	230	15	▲	56.30 (1430)	27.88 (708)	28.43 (722)	5.63 (143)	6.15 (156)	222.3
		3	460	15	▲	56.30 (1430)	27.88 (708)	28.43 (722)	5.63 (143)	6.15 (156)	222.3
300S200-5AA	170	3	230	20	▲	63.71 (1618)	30.83 (783)	32.88 (835)	5.63 (143)	6.15 (156)	194.4
		3	460	20	▲	63.71 (1618)	30.83 (783)	32.88 (835)	5.63 (143)	6.15 (156)	194.4
300S200-5	188	3	230	20	▲	63.71 (1618)	30.83 (783)	32.88 (835)	5.63 (143)	6.15 (156)	194.4
		3	460	20	▲	63.71 (1618)	30.83 (783)	32.88 (835)	5.63 (143)	6.15 (156)	194.4
300S200-6B	211	3	230	20	▲	68.15 (1731)	30.83 (783)	37.33 (948)	5.63 (143)	6.15 (156)	198.0
		3	460	20	▲	68.15 (1731)	30.83 (783)	37.33 (948)	5.63 (143)	6.15 (156)	198.0
300S250-6	228	3	230	25	▲	70.32 (1786)	33.00 (838)	37.33 (948)	5.63 (143)	6.15 (156)	198.0
		3	460	25	▲	70.32 (1786)	33.00 (838)	37.33 (948)	5.63 (143)	6.15 (156)	198.0

300S



E = Maximum diameter of pump including cable guard and motor.

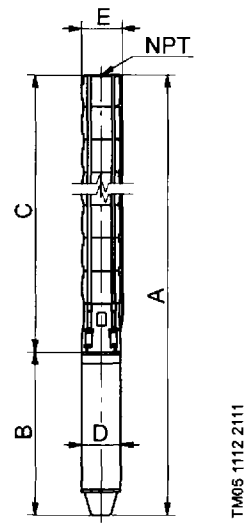
Notes:
Control box is required for 3-wire, single-phase applications. Data does not include control box.
■ MS402 motor.
• MS4000 motor.
▲ MS6 motor.
∧ MMS6000 motor.
★ MMS8000 motor.
♦ Takes MS6 motor; not available as complete.
☼ Takes MMS6000 motor; not available as complete.
* Takes MMS8000 motor; not available as complete.
† Takes MMS10000 motor; not available as complete.

300S (300 gpm)

Pump model	Nom. head [ft]	Ph	Volts [V]	Motor [Hp]		Dimensions A [in (mm)]	B [in (mm)]	C [in (mm)]	D [in (mm)]	E [in (mm)]	Net weight (complete) [lb]
300S - Motor dia. 6 inch, 3 wire motor, 60 Hz, rated flow 300 gpm (4" NPT)											
300S250-7AA	249	3	230	25	▲	74.77 (1899)	33.00 (838)	41.78 (1061)	5.63 (143)	6.15 (156)	217.8
		3	460	25	▲	74.77 (1899)	33.00 (838)	41.78 (1061)	5.63 (143)	6.15 (156)	217.8
300S300-7	267	3	230	25	▲	77.33 (1964)	35.56 (903)	41.78 (1061)	5.63 (143)	6.15 (156)	217.8
		3	460	25	▲	77.33 (1964)	35.56 (903)	41.78 (1061)	5.63 (143)	6.15 (156)	217.8
300S300-8	307	3	230	30	▲	81.78 (2077)	35.56 (903)	46.23 (1174)	5.63 (143)	6.15 (156)	224.1
		3	460	30	▲	81.78 (2077)	35.56 (903)	46.23 (1174)	5.63 (143)	6.15 (156)	224.1
300S300-9B	329	3	230	30	▲	86.23 (2190)	35.56 (903)	50.67 (1287)	5.63 (143)	6.15 (156)	261.0
		3	460	30	▲	86.23 (2190)	35.56 (903)	50.67 (1287)	5.63 (143)	6.15 (156)	261.0
300S400-9	346	3	460	40	▲	90.95 (2310)	40.28 (1023)	50.67 (1287)	5.63 (143)	6.15 (156)	296.0
300S400-10	385	3	460	40	▲	95.40 (2423)	40.28 (1023)	55.12 (1400)	5.63 (143)	6.15 (156)	300.5
300S500-11	425	3	460	50	☼	115.67 (2938)	56.11 (1425)	59.57 (1513)	5.67 (144)	6.15 (156)	352.0
300S500-12	464	3	460	50	☼	120.12 (3051)	56.11 (1425)	64.02 (1626)	5.67 (144)	6.15 (156)	348.8
300S500-13	504	3	460	50	☼	124.57 (3164)	56.11 (1425)	68.47 (1739)	5.67 (144)	6.15 (156)	355.1
300S600-14	543	3	460	60	☼	—	—	74.06 (1881)	—	6.15 (156)	—
300S600-15	582	3	460	60	☼	—	—	74.06 (1881)	—	6.15 (156)	—
SP 300S - Motor dia. 8 inch, 3 wire motor, 60 Hz, rated flow 230 gpm (4" NPT)											
300S600-14	543	3	460	60	*	124.06 (3151)	50.00 (1270)	74.06 (1881)	7.56 (192)	7.56 (192)	479.4
300S600-15	582	3	460	60	*	128.51 (3264)	50.00 (1270)	78.51 (1994)	7.56 (192)	7.56 (192)	519.4
300S750-16	622	3	460	75	*	136.11 (3457)	53.15 (1350)	82.96 (2107)	7.56 (192)	7.56 (192)	569.1
300S750-17	661	3	460	75	*	140.56 (3570)	53.15 (1350)	87.41 (2220)	7.56 (192)	7.56 (192)	575.4
300S750-18	701	3	460	75	*	145.00 (3683)	53.15 (1350)	91.86 (2333)	7.56 (192)	7.56 (192)	581.7

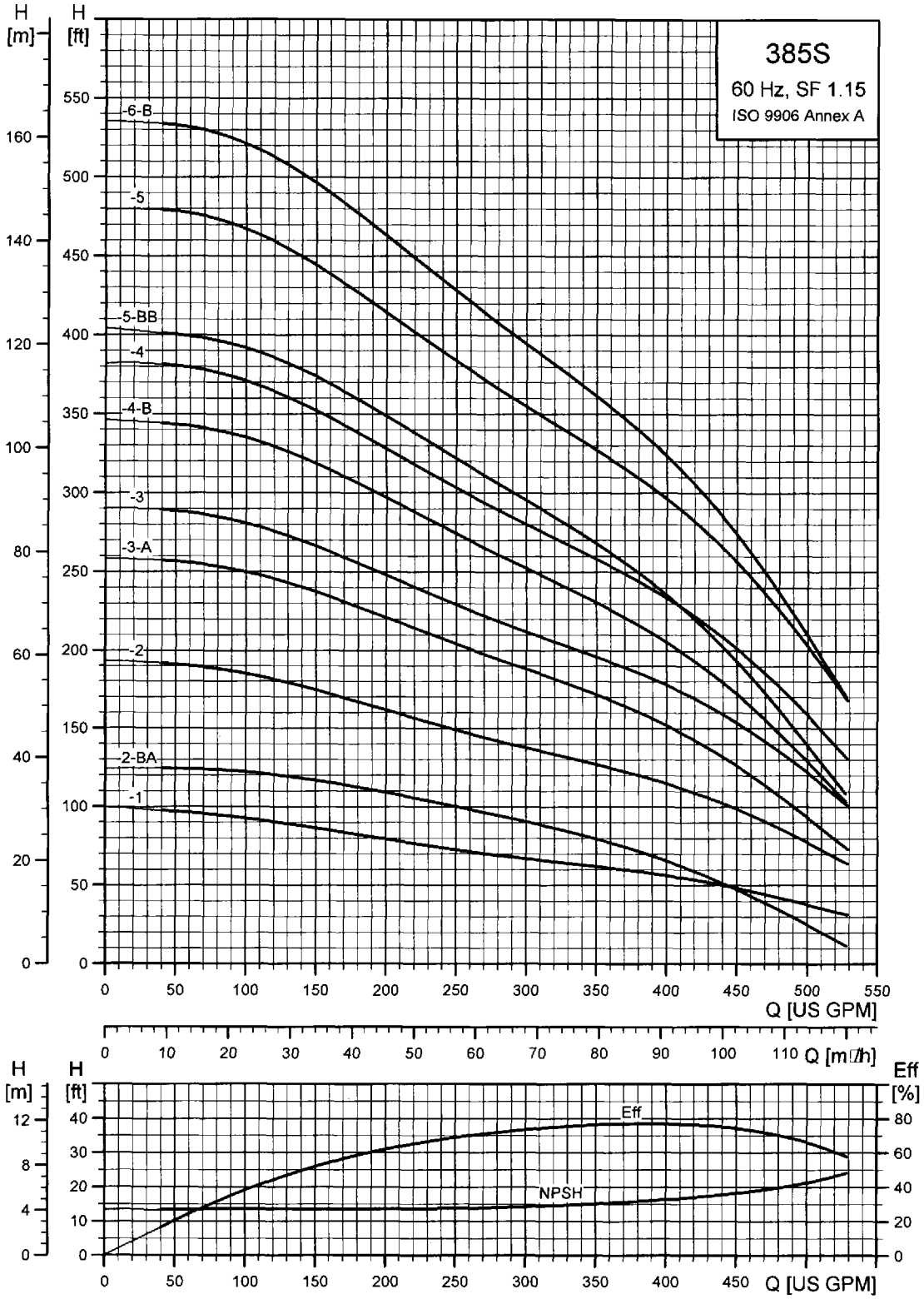
Notes:
Control box is required for 3-wire, single-phase applications. Data does not include control box.
- ■ MS402 motor.
- ● MS4000 motor.
- ▲ MS6 motor.
- ∧ MMS6000 motor.
- ★ MMS8000 motor.
- ♦ Takes MS6 motor; not available as complete.
- ☼ Takes MMS6000 motor; not available as complete.
- * Takes MMS8000 motor; not available as complete.
- †Takes MMS10000 motor; not available as complete.

300S



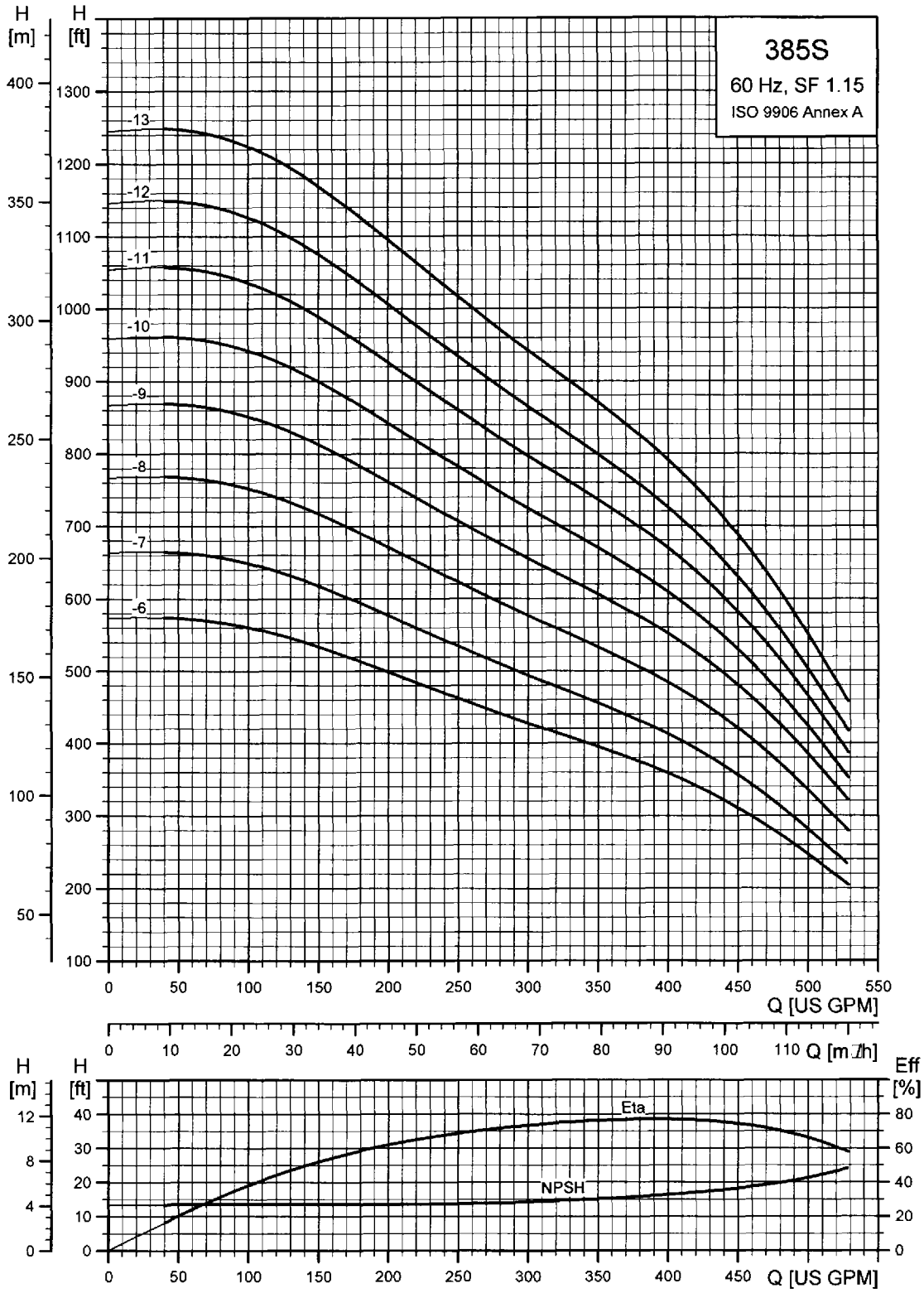
E = Maximum diameter of pump including cable guard and motor.

385S (385 gpm)



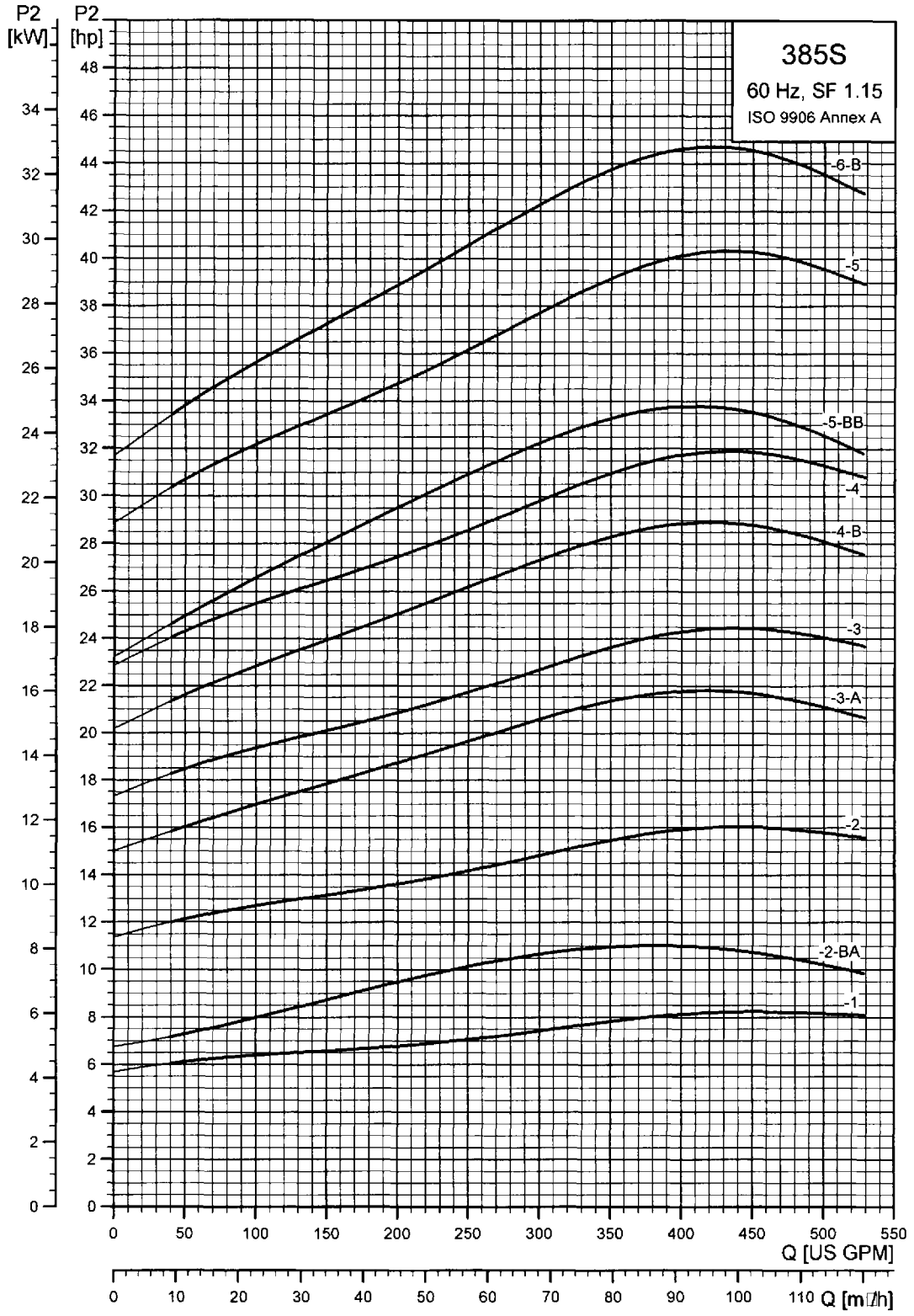
TM05 0251 0112

385S (385 gpm)



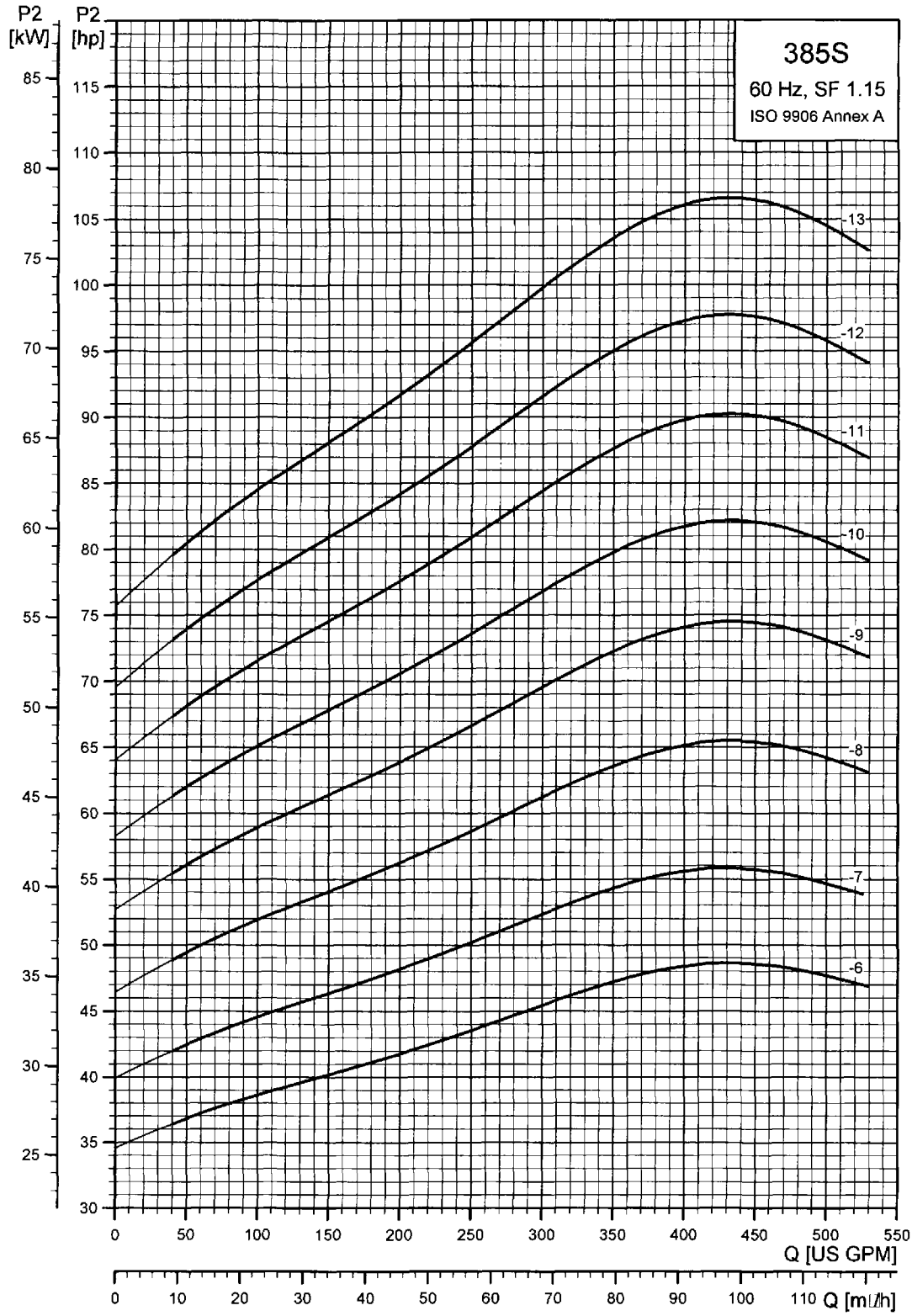
TM05 0252 0112

385S (385 gpm) pump power requirement (P2)



TM05 0253 0112

385S (385 gpm) pump power requirement (P2)

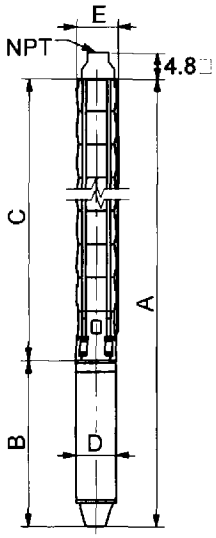


TM05 0254 0112

385S (385 gpm)

Pump model	Nom. head [ft]	Ph	Volts [V]	Motor [Hp]		Dimensions A [in (mm)]	B [in (mm)]	C [in (mm)]	D [in (mm)]	E [in (mm)]	Net weight (complete) [lb]
385S - Motor dia. 6 inch, 3 wire motor, 60 Hz, rated flow 385 gpm (4" NPT)											
385S75-1	57	3	230	7.5	▲	46.58 (1183)	22.25 (565)	24.34 (618)	5.63 (143)	7.01 (178)	135.9
		3	460	7.5	▲	46.58 (1183)	22.25 (565)	24.34 (618)	5.63 (143)	7.01 (178)	135.9
385S100-2BA	69	3	230	10	▲	52.6 (1336)	23.23 (590)	29.38 (746)	5.63 (143)	7.01 (178)	169.2
		3	460	10	▲	52.6 (1336)	23.23 (590)	29.38 (746)	5.63 (143)	7.01 (178)	169.2
385S150-2	117	3	230	18	▲	57.25 (1454)	27.88 (708)	29.38 (746)	5.63 (143)	7.01 (178)	169.2
		3	460	18	▲	57.25 (1454)	27.88 (708)	29.38 (746)	5.63 (143)	7.01 (178)	169.2
385S200-3A	155	3	230	20	▲	65.24 (1657)	30.83 (783)	34.41 (874)	5.63 (143)	7.01 (178)	188.1
		3	460	20	▲	65.24 (1657)	30.83 (783)	34.41 (874)	5.63 (143)	7.01 (178)	188.1
385S250-3	177	3	230	25	▲	67.41 (1712)	33.00 (838)	34.41 (874)	5.63 (143)	7.01 (178)	188.1
		3	460	25	▲	67.41 (1712)	33.00 (838)	34.41 (874)	5.63 (143)	7.01 (178)	188.1
385S250-4B	210	3	230	25	▲	72.45 (1840)	33.00 (838)	39.45 (1002)	5.63 (143)	7.01 (178)	239.4
		3	460	25	▲	72.45 (1840)	33.00 (838)	39.45 (1002)	5.63 (143)	7.01 (178)	239.4
385S300-4	237	3	230	30	▲	75.00 (1905)	35.56 (903)	39.45 (1002)	5.63 (143)	7.01 (178)	239.4
		3	460	30	▲	75.00 (1905)	35.56 (903)	39.45 (1002)	5.63 (143)	7.01 (178)	239.4
385S300-5BB	343	3	230	30	▲	80.04 (2033)	35.56 (903)	44.49 (1130)	5.63 (143)	7.01 (178)	247.5
		3	460	30	▲	80.04 (2033)	35.56 (903)	44.49 (1130)	5.63 (143)	7.01 (178)	247.5
385S400-5	297	3	460	40	▲	84.77 (2153)	40.28 (1023)	44.49 (1130)	5.63 (143)	7.01 (178)	247.5
385S400-6B	330	3	460	40	▲	89.81 (2281)	40.28 (1023)	49.53 (1258)	5.63 (143)	7.01 (178)	252.0
385S500-6	357	3	460	50	☼	110.99 (2825)	56.11 (1425)	54.88 (1394)	5.67 (144)	7.88 (200)	—
385S500-7A	400	3	460	50	☼	110.99 (2825)	56.11 (1425)	54.88 (1394)	5.67 (144)	7.88 (200)	—
385S600-7	416	3	460	60	♦	—	—	55.12 (1400)	—	7.88 (200)	—
385S600-8	476	3	460	60	♦	—	—	55.12 (1400)	—	7.88 (200)	—
385S - Motor dia. 8 inch, 3 wire motor, 60 Hz, rated flow 385 gpm (4" NPT)											
385S400-6B	330	3	460	40	*	93.78 (2382)	43.71 (1110)	50.08 (1272)	7.56 (192)	7.88 (200)	428.3
385S500-6	357	3	460	50	*	95.75 (2432)	45.67 (1160)	50.08 (1272)	7.56 (192)	7.88 (200)	451.2
385S500-7A	400	3	460	50	*	100.79 (2560)	45.67 (1160)	55.12 (1400)	7.56 (192)	7.88 (200)	461.1
385S600-7	416	3	460	60	*	105.12 (2670)	50.00 (1270)	55.12 (1400)	7.56 (192)	7.88 (200)	507.3
385S600-8	476	3	460	60	*	110.16 (2798)	50.00 (1270)	60.16 (1528)	7.56 (192)	7.88 (200)	517.2
385S750-9	536	3	460	75	*	118.35 (3006)	53.15 (1350)	65.2 (1656)	7.56 (192)	7.88 (200)	558.7
385S750-10	596	3	460	75	*	123.39 (3134)	53.15 (1350)	70.24 (1784)	7.56 (192)	7.88 (200)	568.6
385S1000-11	656	3	460	100	*	137.88 (3502)	62.60 (1590)	75.28 (1912)	7.56 (192)	7.88 (200)	677.5
385S1000-12	716	3	460	100	*	142.92 (3630)	62.60 (1590)	80.32 (2040)	7.56 (192)	7.88 (200)	687.4
385S1000-13	776	3	460	100	*	147.96 (3758)	62.60 (1590)	85.36 (2168)	7.56 (192)	7.88 (200)	697.3

385S



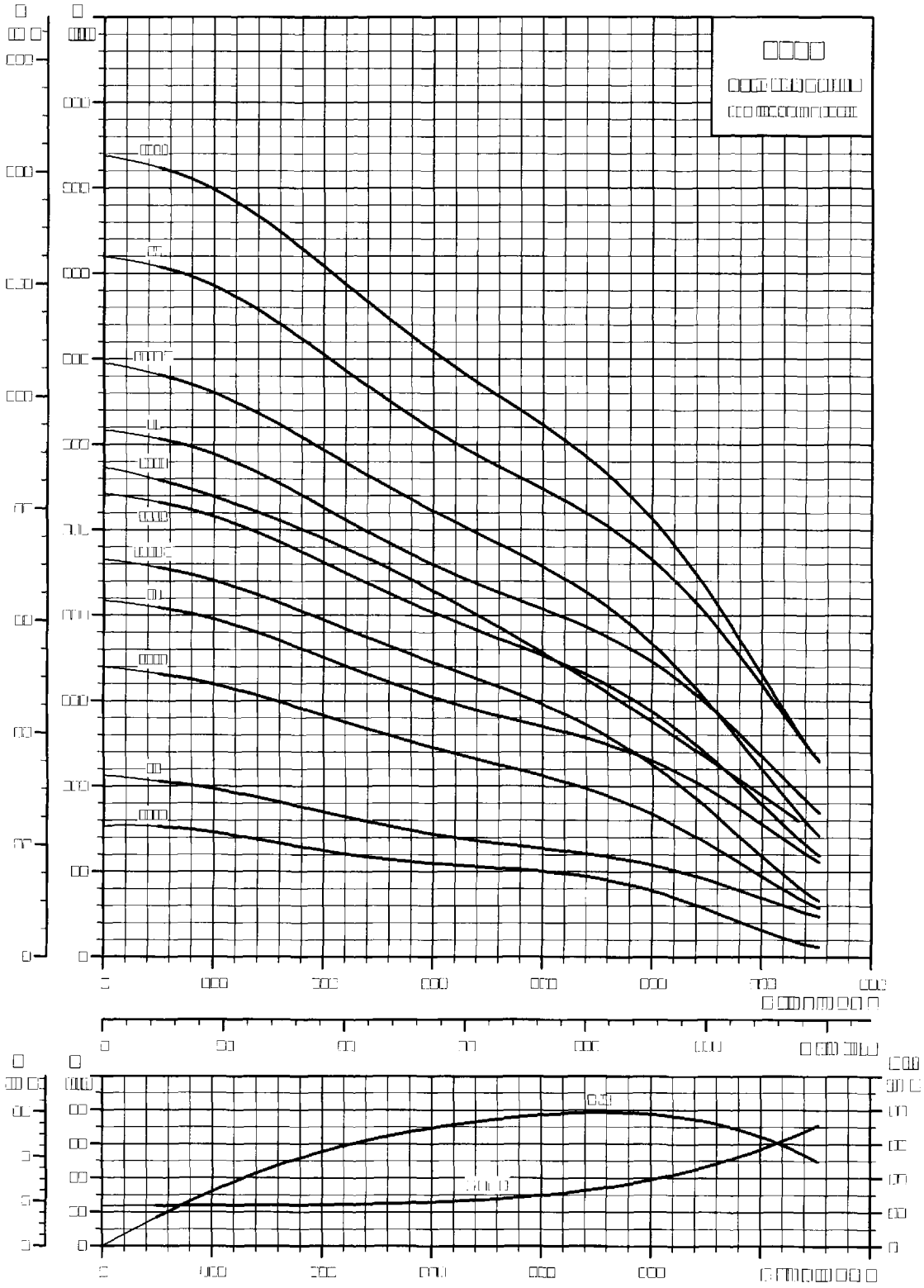
TM05 2530 0212

E = Maximum diameter of pump including cable guard and motor.

Notes:
Control box is required for 3-wire, single-phase applications. Data does not include control box.

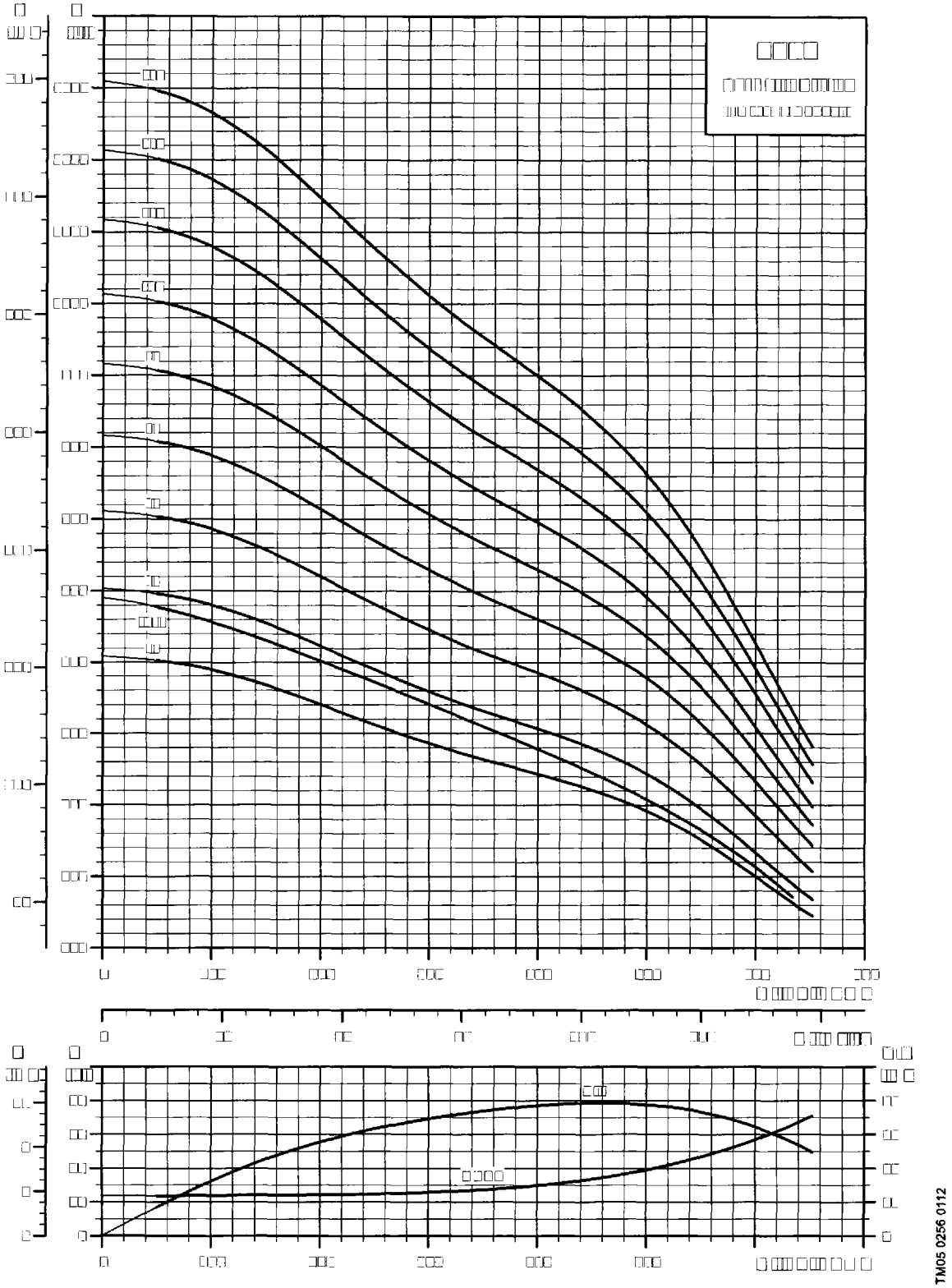
- ■ MS402 motor.
- ● MS4000 motor.
- ▲ MS6 motor.
- ∧ MMS6000 motor.
- ★ MMS8000 motor.
- ♦ Takes MS6 motor; not available as complete.
- ☼ Takes MMS6000 motor; not available as complete.
- * Takes MMS8000 motor; not available as complete.
- † Takes MMS10000 motor; not available as complete.

475S (475 gpm)



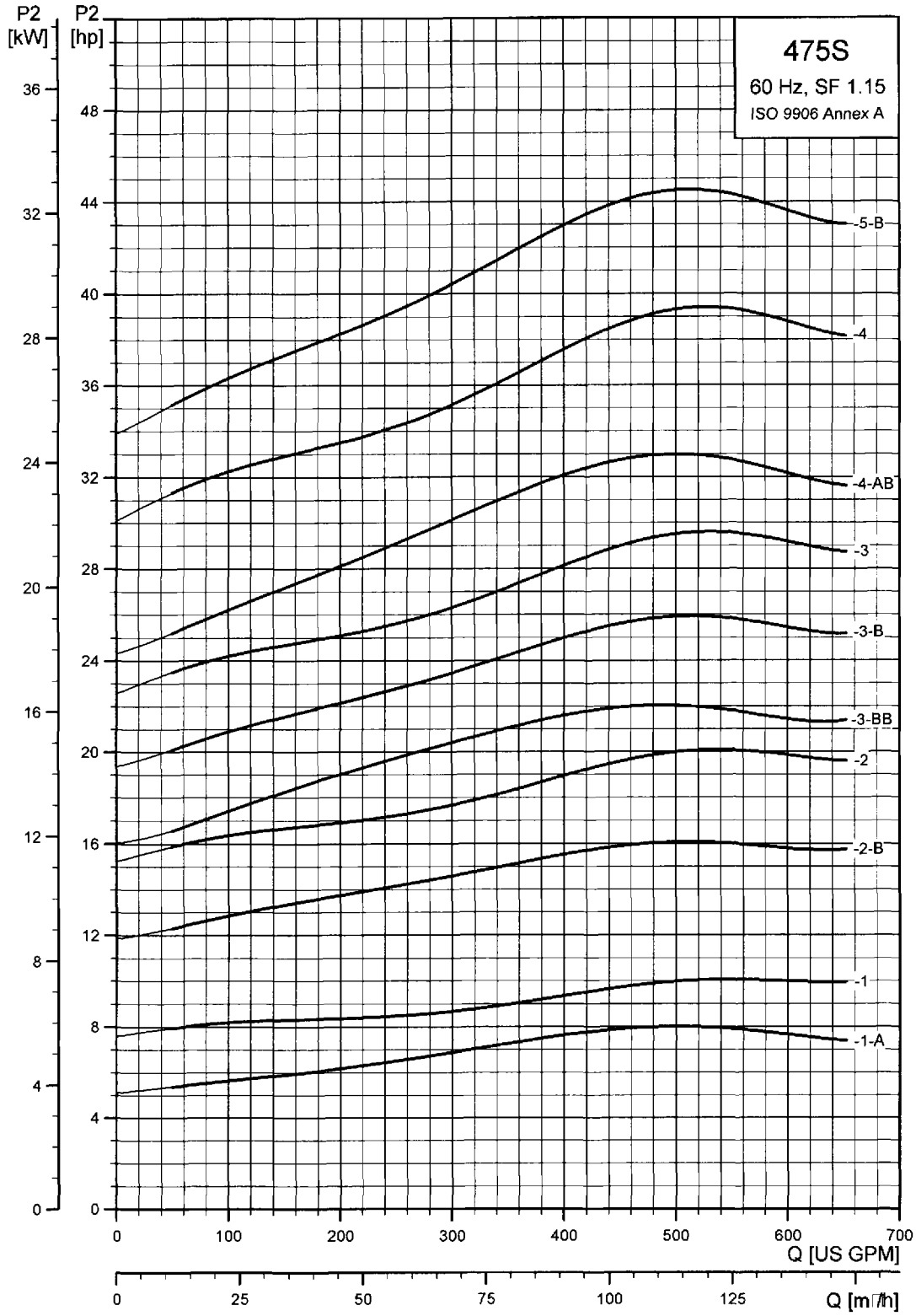
TM05 0255 0112

475S (475 gpm)



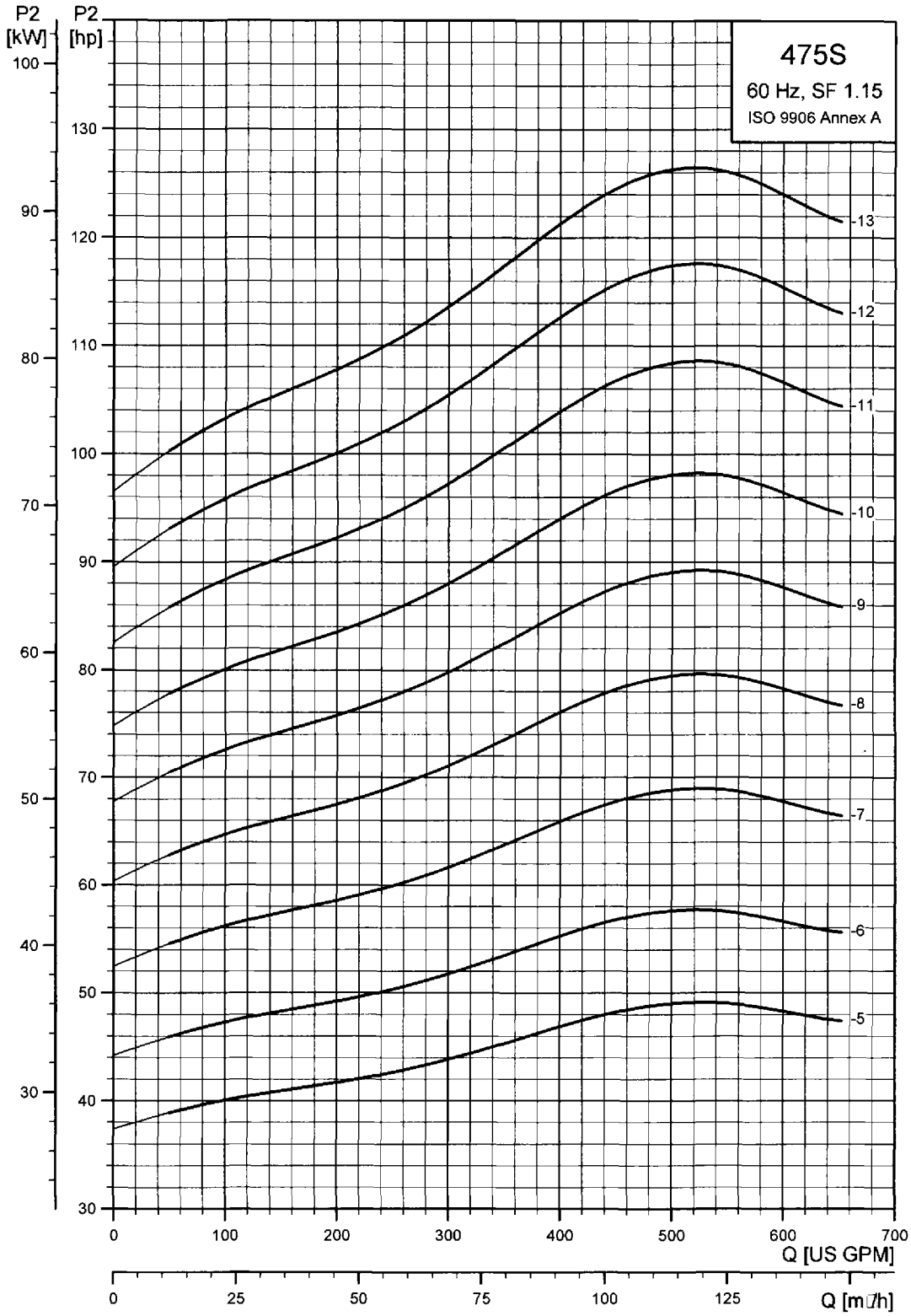
TM05 0256 0112

475S (475 gpm) pump power requirement (P2)



TM05 0257 0112

475S (475 gpm) pump power requirement (P2)

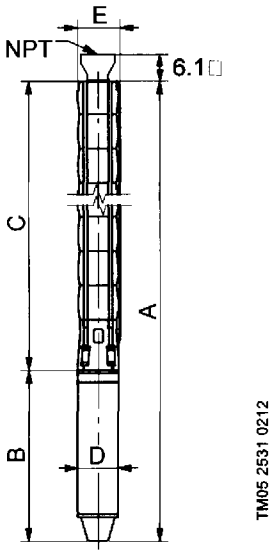


TM05 0258 0112

475S (475 gpm)

Pump model	Nom. head [ft]	Ph	Volts [V]	Motor [Hp]		Dimensions A [in (mm)]	B [in (mm)]	C [in (mm)]	D [in (mm)]	E [in (mm)]	Net weight (complete) [lb]
475S - Motor dia. 6 inch, 3 wire motor, 60 Hz, rated flow 475 gpm (5" NPT)											
475S75-1A	42	3	230	7.5	▲	46.58 (1183)	22.25 (565)	24.34 (618)	5.63 (143)	7.05 (179)	132.3
		3	460	7.5	▲	46.58 (1183)	22.25 (565)	24.34 (618)	5.63 (143)	7.05 (179)	132.3
475S100-1	58	3	230	10	▲	47.56 (1208)	23.23 (590)	24.34 (618)	5.63 (143)	7.05 (179)	132.3
		3	460	10	▲	47.56 (1208)	23.23 (590)	24.34 (618)	5.63 (143)	7.05 (179)	132.3
475S150-2B	89	3	230	15	▲	57.25 (1454)	27.88 (708)	29.38 (746)	5.63 (143)	7.05 (179)	170.1
		3	460	15	▲	57.25 (1454)	27.88 (708)	29.38 (746)	5.63 (143)	7.05 (179)	170.1
475S200-2	117	3	230	20	▲	60.20 (1529)	30.83 (783)	29.38 (746)	5.63 (143)	7.05 (179)	198.7
		3	460	20	▲	60.20 (1529)	30.83 (783)	29.38 (746)	5.63 (143)	7.05 (179)	198.7
475S250-3A	166	3	230	25	▲	67.41 (1712)	33.00 (838)	34.41 (874)	5.63 (143)	7.05 (179)	218.2
		3	460	25	▲	67.41 (1712)	33.00 (838)	34.41 (874)	5.63 (143)	7.05 (179)	218.2
475S300-3	177	3	230	30	▲	69.97 (1777)	35.56 (903)	34.41 (874)	5.63 (143)	7.05 (179)	233.6
		3	460	30	▲	69.97 (1777)	35.56 (903)	34.41 (874)	5.63 (143)	7.05 (179)	233.6
475S300-4AB	168	3	230	30	▲	75.00 (1905)	35.56 (903)	39.45 (1002)	5.63 (143)	7.05 (179)	239.9
		3	460	30	▲	75.00 (1905)	35.56 (903)	39.45 (1002)	5.63 (143)	7.05 (179)	239.9
475S400-4	236	3	460	40	▲	79.73 (2025)	40.28 (1023)	39.45 (1002)	5.63 (143)	7.05 (179)	268.5
475S - Motor dia. 6 inch, 3 wire motor, 60 Hz, rated flow 475 gpm (6" NPT)											
475S400-5B	268	3	460	40	▲	84.77 (2153)	40.28 (1023)	44.49 (1130)	5.63 (143)	7.05 (179)	356.0
475S500-5	296	3	460	50	☼	100.6 (2555)	56.11 (1425)	44.49 (1130)	5.67 (144)	7.05 (179)	384.0
475S500-6A	344	3	460	50	☼	105.63 (2683)	56.11 (1425)	49.53 (1258)	5.67 (144)	7.05 (179)	385.0
475S600-6	355	3	460	60	♦	—	—	50.08 (1272)	—	7.05 (179)	—
475S600-7	415	3	460	60	♦	—	—	55.12 (1400)	—	7.05 (179)	—
475S - Motor dia. 8 inch, 3 wire motor, 60 Hz, rated flow 475 gpm (6" NPT)											
475S400-4	236	3	460	40	*	83.71 (2126)	43.71 (1110)	40.00 (1016)	7.56 (192)	8.08 (205)	406.5
475S400-5B	268	3	460	40	*	88.75 (2254)	43.71 (1110)	45.04 (1144)	7.56 (192)	8.08 (205)	—
475S500-5	296	3	460	50	*	90.71 (2304)	45.67 (1160)	45.04 (1144)	7.56 (192)	8.08 (205)	420.4
475S500-6A	344	3	460	50	*	95.75 (2432)	45.67 (1160)	50.08 (1272)	7.56 (192)	8.08 (205)	—
475S600-6	355	3	460	60	*	100.08 (2542)	50.00 (1270)	50.08 (1272)	7.56 (192)	8.08 (205)	476.0
475S600-7	415	3	460	60	*	105.12 (2670)	50.00 (1270)	55.12 (1400)	7.56 (192)	8.08 (205)	482.6
475S750-8	534	3	460	75	*	113.31 (2878)	53.15 (1350)	60.16 (1528)	7.56 (192)	8.08 (205)	524.4
475S1000-9	534	3	460	100	*	127.8 (3246)	62.60 (1590)	65.20 (1656)	7.56 (192)	8.08 (205)	631.0
475S1000-10	593	3	460	100	*	132.84 (3374)	62.60 (1590)	70.24 (1784)	7.56 (192)	8.08 (205)	637.6
475S1000-11	653	3	460	100	*	137.88 (3502)	62.60 (1590)	75.28 (1912)	7.56 (192)	8.08 (205)	644.3
475S1250-12	712	3	460	125	*	152.37 (3870)	72.05 (1830)	80.32 (2040)	7.56 (192)	8.08 (205)	754.1
475S1250-13	772	3	460	125	*	157.41 (3998)	72.05 (1830)	85.36 (2168)	7.56 (192)	8.08 (205)	760.7

475S

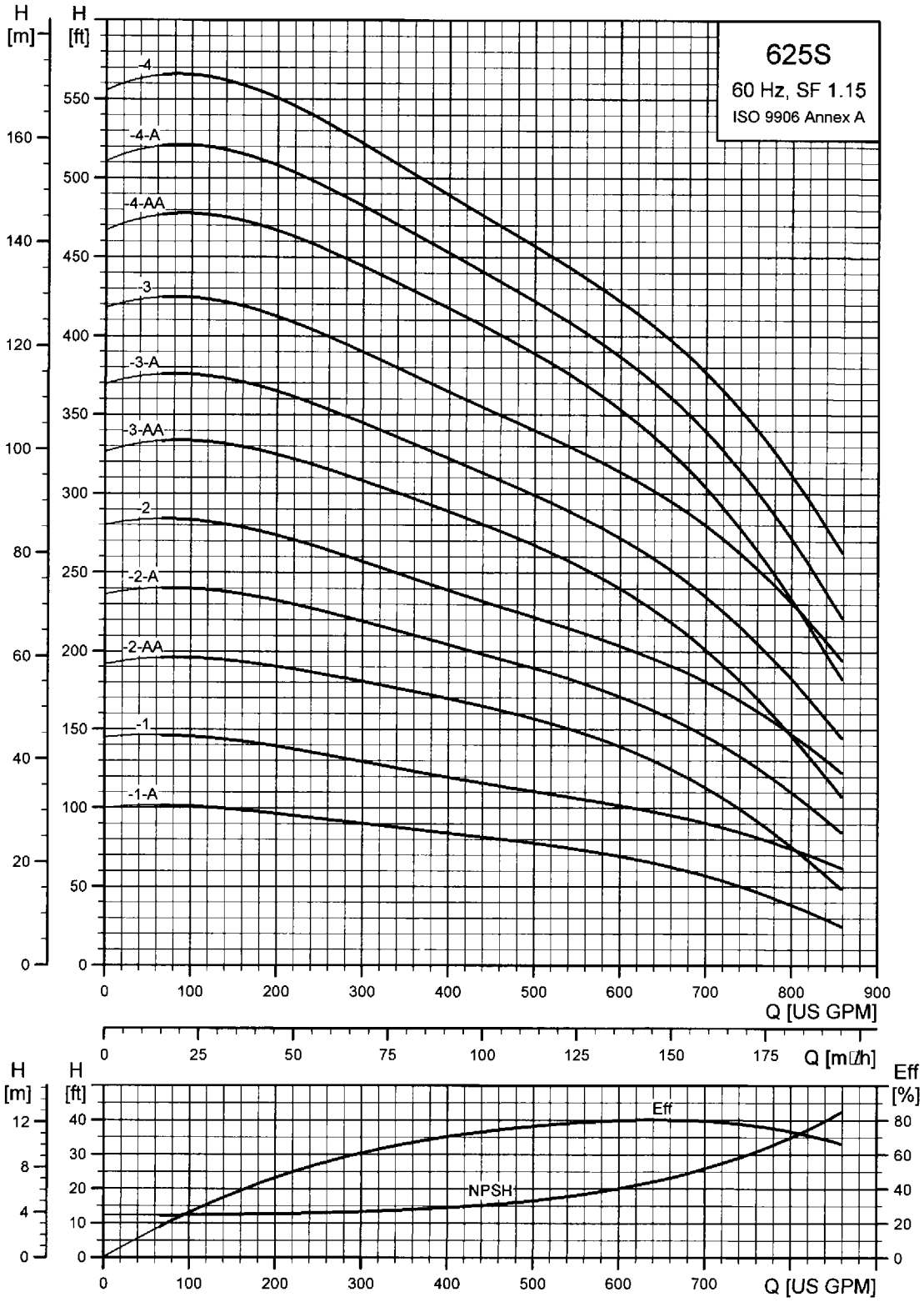


E = Maximum diameter of pump including cable guard and motor.

Notes:
Control box is required for 3-wire, single-phase applications. Data does not include control box.

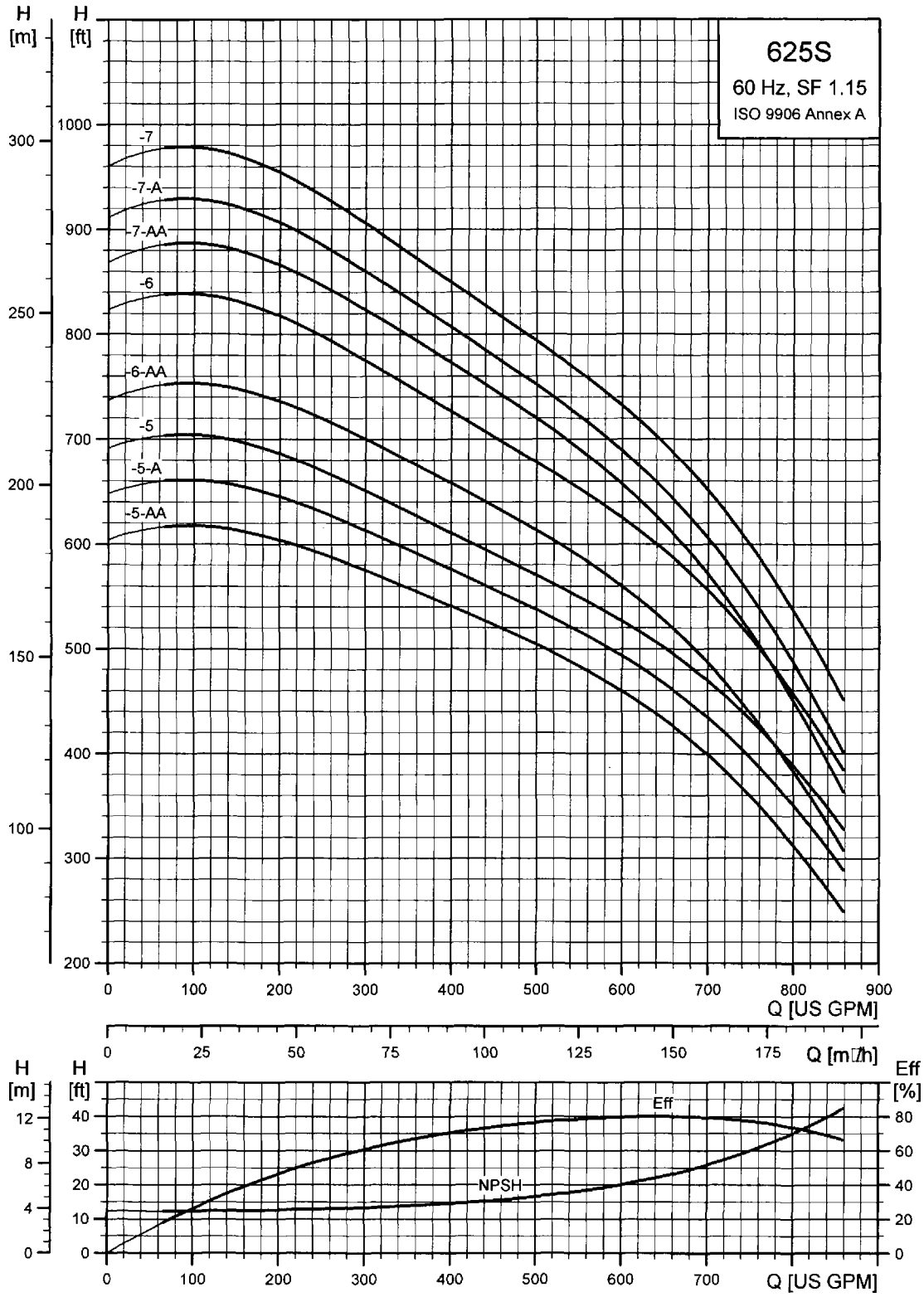
- ■ MS402 motor.
- ● MS4000 motor.
- ▲ MS6 motor.
- ∧ MMS6000 motor.
- ★ MMS8000 motor.
- ♦ Takes MS6 motor; not available as complete.
- ☼ Takes MMS6000 motor; not available as complete.
- * Takes MMS8000 motor; not available as complete.
- † Takes MMS10000 motor; not available as complete.

625S (625 gpm)



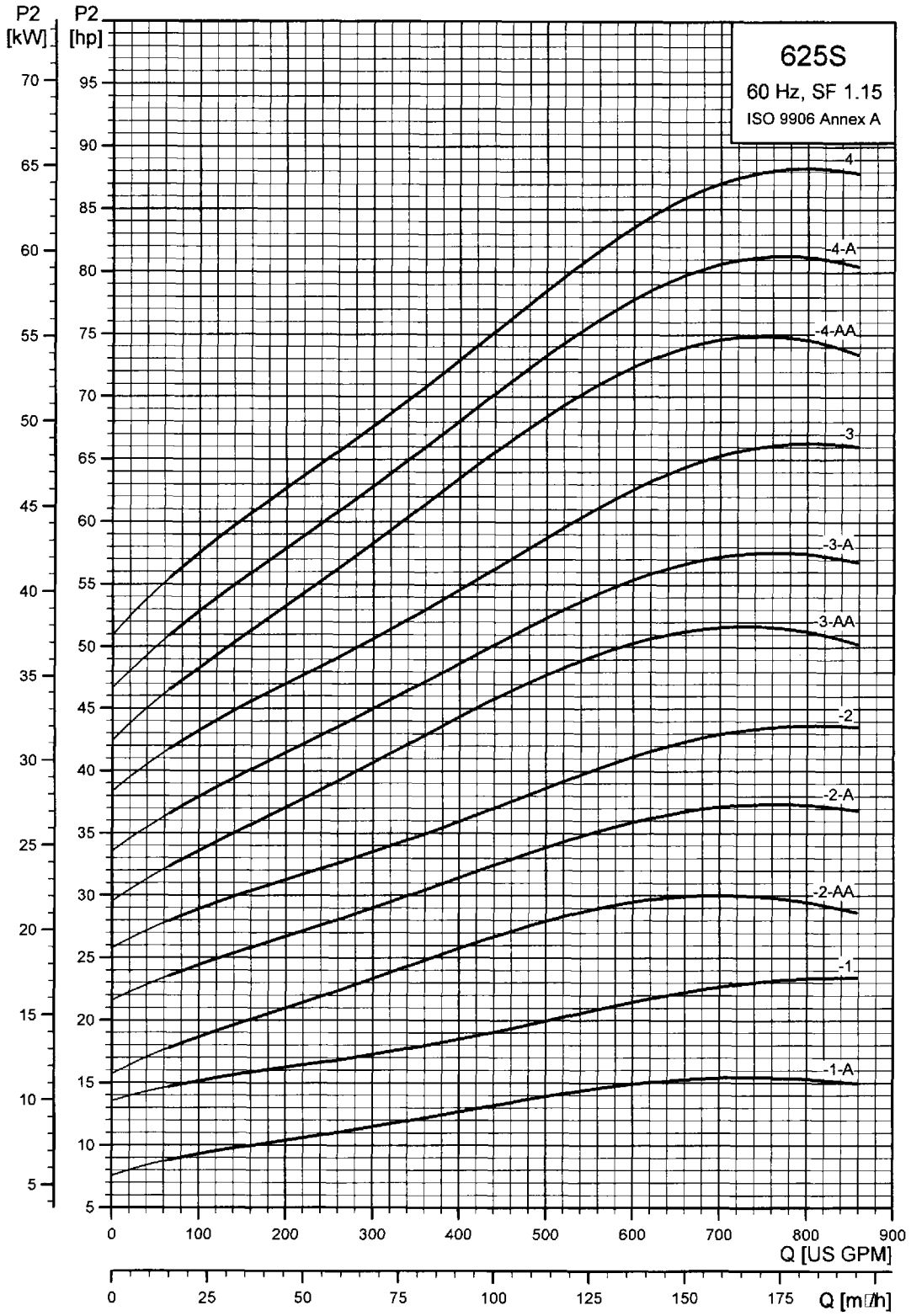
TM05 0259 0112

625S (625 gpm)



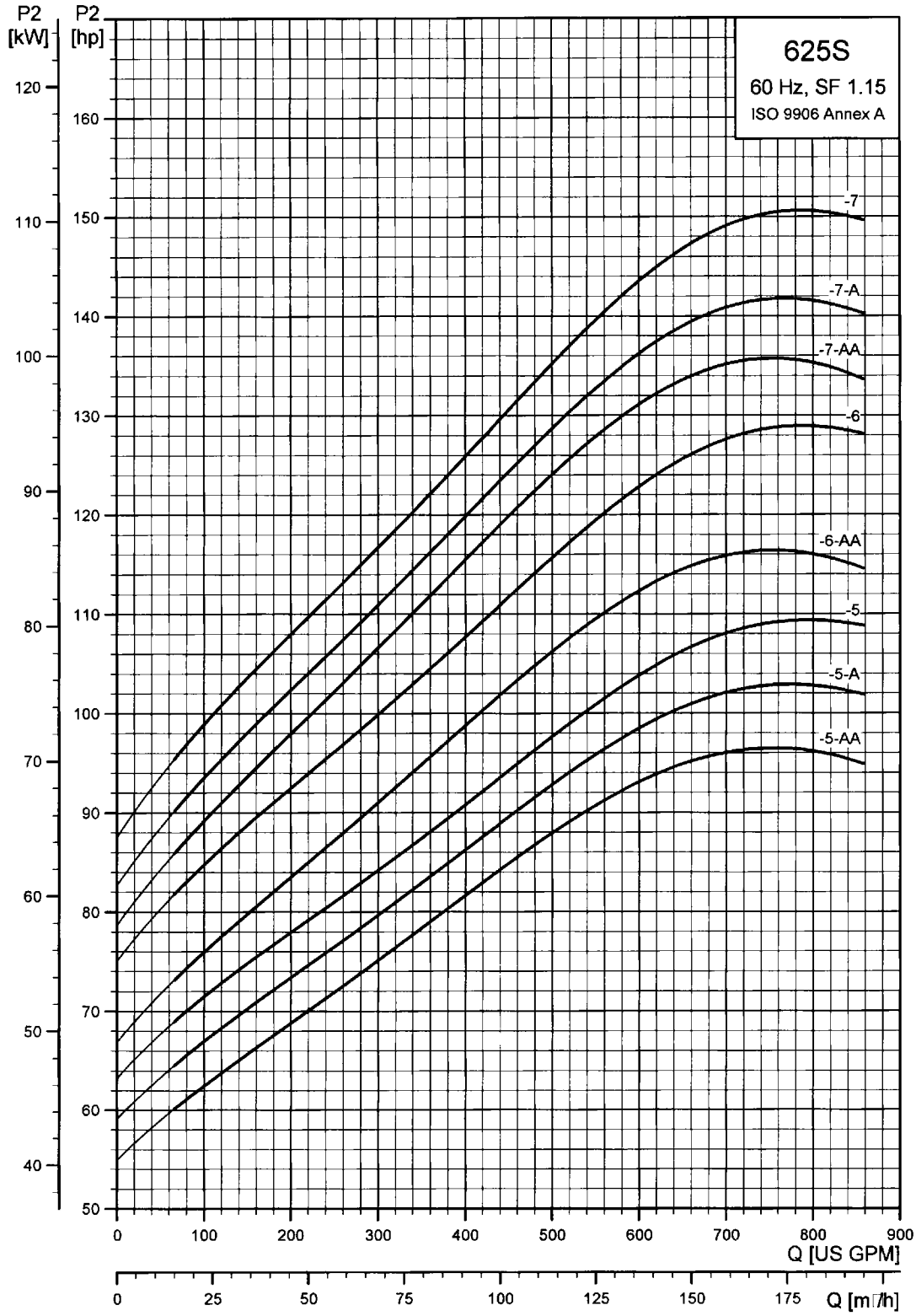
TM05 0260 0112

625S (625 gpm) pump power requirement (P2)



TM05 0261 0112

625S (625 gpm) pump power requirement (P2)

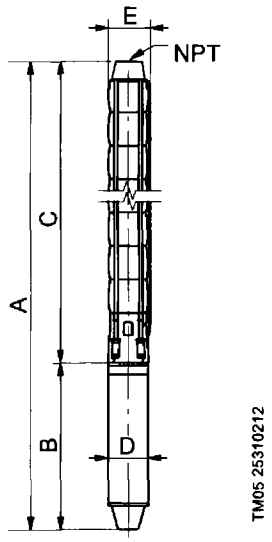


TM05 0262 0112

625S (625 gpm)

Pump model	Nom. head [ft]	Ph	Volts [V]	Motor [Hp]		Dimensions A [in (mm)]	B [in (mm)]	C [in (mm)]	D [in (mm)]	E [in (mm)]	Net weight (complete) [lb]
625S - Motor dia. 6 inch, 3 wire motor, 60 Hz, rated flow 625 gpm (6" NPT)											
625S150-1A	65	3	230	15	▲	53.51 (1359)	27.88 (708)	25.63 (651)	5.63 (143)	8.31 (211)	193.0
		3	460	15	▲	53.51 (1359)	27.88 (708)	25.63 (651)	5.63 (143)	8.31 (211)	193.0
625S250-1	95	3	230	25	▲	58.63 (1489)	33.00 (838)	25.63 (651)	5.63 (143)	8.31 (211)	189.9
		3	460	25	▲	58.63 (1489)	33.00 (838)	25.63 (651)	5.63 (143)	8.31 (211)	198.9
625S300-2AA	130	3	230	30	▲	67.33 (1710)	35.56 (903)	31.78 (807)	5.63 (143)	8.31 (211)	213.0
		3	460	30	▲	67.33 (1710)	35.56 (903)	31.78 (807)	5.63 (143)	8.31 (211)	222.3
625S400-2A	159	3	460	40	▲	72.05 (1830)	40.28 (1023)	31.78 (807)	5.63 (143)	8.31 (211)	333.8
625S400-2	194	3	460	40	▲	72.05 (1830)	40.28 (1023)	31.78 (807)	5.63 (143)	8.31 (211)	333.8
625S500-3AA	224	3	460	50	♦	94.02 (2388)	56.11 (1425)	37.94 (963)	5.63 (143)	8.31 (211)	376.4
625S600-3A	258	3	460	60	♦	—	—	37.92 (963)	—	8.31 (211)	—
625S600-3	292	3	460	60	♦	—	—	37.92 (963)	—	8.31 (211)	—
625S - Motor dia. 8 inch, 3 wire motor, 60 Hz, rated flow 625 gpm (6" NPT)											
625S400-2	194	3	460	40	*	76.03 (1931)	43.71 (1110)	32.33 (821)	7.56 (192)	8.39 (213)	409.4
625S500-3AA	224	3	460	50	*	83.59 (2123)	45.67 (1160)	37.92 (963)	7.56 (192)	8.39 (213)	444.6
625S600-3A	258	3	460	60	*	87.92 (2233)	50.00 (1270)	37.92 (963)	7.56 (192)	8.39 (213)	490.8
625S600-3	292	3	460	60	*	87.92 (2233)	50.00 (1270)	37.92 (963)	7.56 (192)	8.39 (213)	490.8
625S750-4AA	322	3	460	75	*	97.21 (2469)	53.15 (1350)	44.06 (1119)	7.56 (192)	8.39 (213)	534.8
625S750-4A	357	3	460	75	*	97.21 (2469)	53.15 (1350)	44.06 (1119)	7.56 (192)	8.39 (213)	534.8
625S1000-4	391	3	460	100	*	106.66 (2709)	62.60 (1590)	44.06 (1119)	7.56 (192)	8.39 (213)	633.8
6251000-5AA	421	3	460	100	*	112.76 (2864)	62.60 (1590)	50.16 (1274)	7.56 (192)	8.39 (213)	649.3
625S1000-5A	455	3	460	100	*	112.76 (2864)	62.60 (1590)	50.16 (1274)	7.56 (192)	8.39 (213)	649.3
625S1000-5	490	3	460	100	*	112.76 (2864)	62.60 (1590)	50.16 (1274)	7.56 (192)	8.39 (213)	649.3
625S1250-6AA	520	3	460	125	*	128.31 (3259)	72.05 (1830)	56.26 (1429)	7.56 (192)	8.39 (213)	761.5
625S1250-6	554	3	460	125	*	128.31 (3259)	72.05 (1830)	56.26 (1429)	7.56 (192)	8.39 (213)	761.5
625S1250-7AA	618	3	460	125	*	134.45 (3415)	72.05 (1830)	62.41 (1585)	7.56 (192)	8.39 (213)	774.7
625S1500-7A	653	3	460	150	*	143.51 (3645)	81.11 (2060)	62.41 (1585)	7.56 (192)	8.39 (213)	884.7
625S1500-7	687	3	460	150	*	143.51 (3645)	81.11 (2060)	62.41 (1585)	7.56 (192)	8.39 (213)	884.7

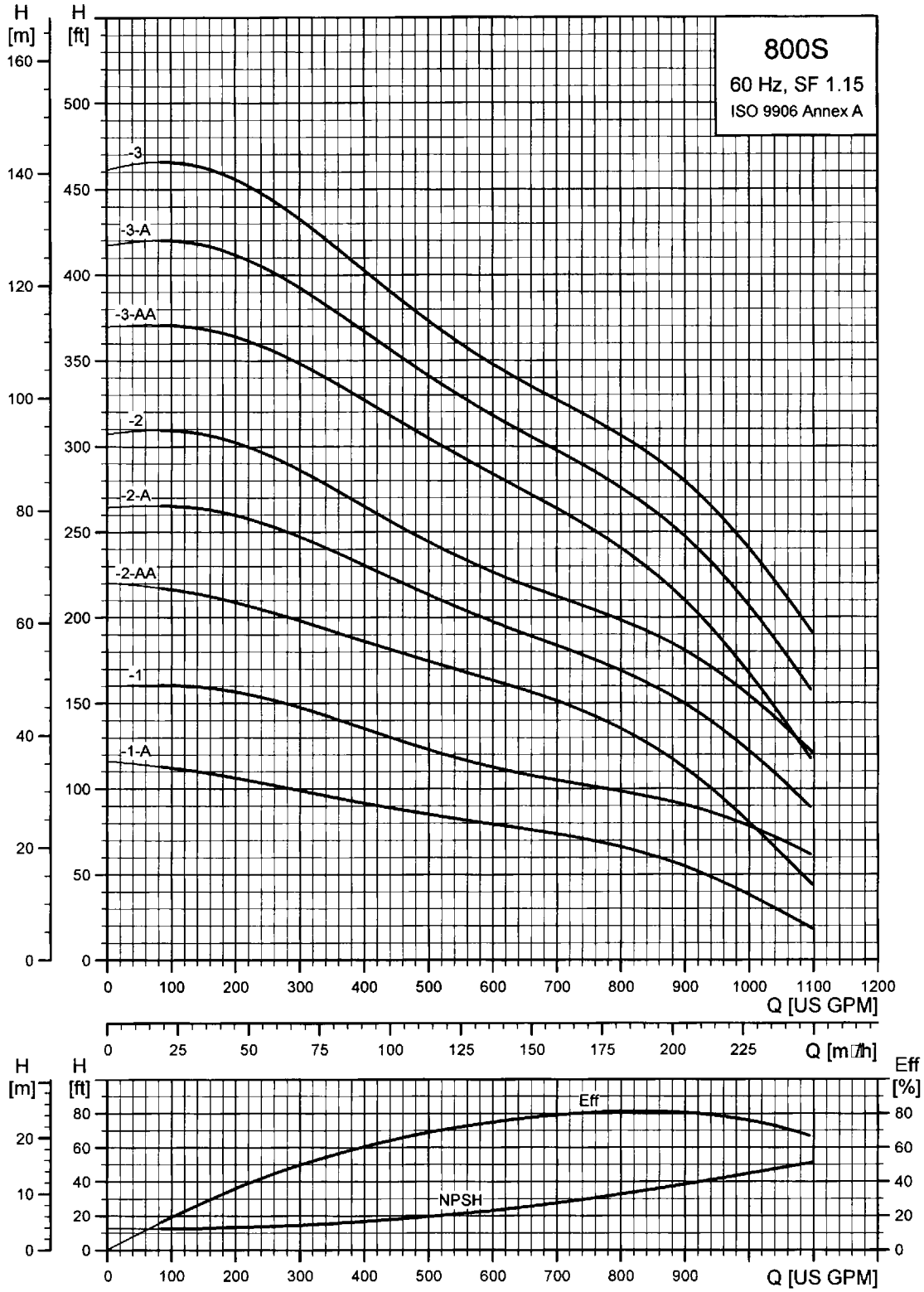
625S



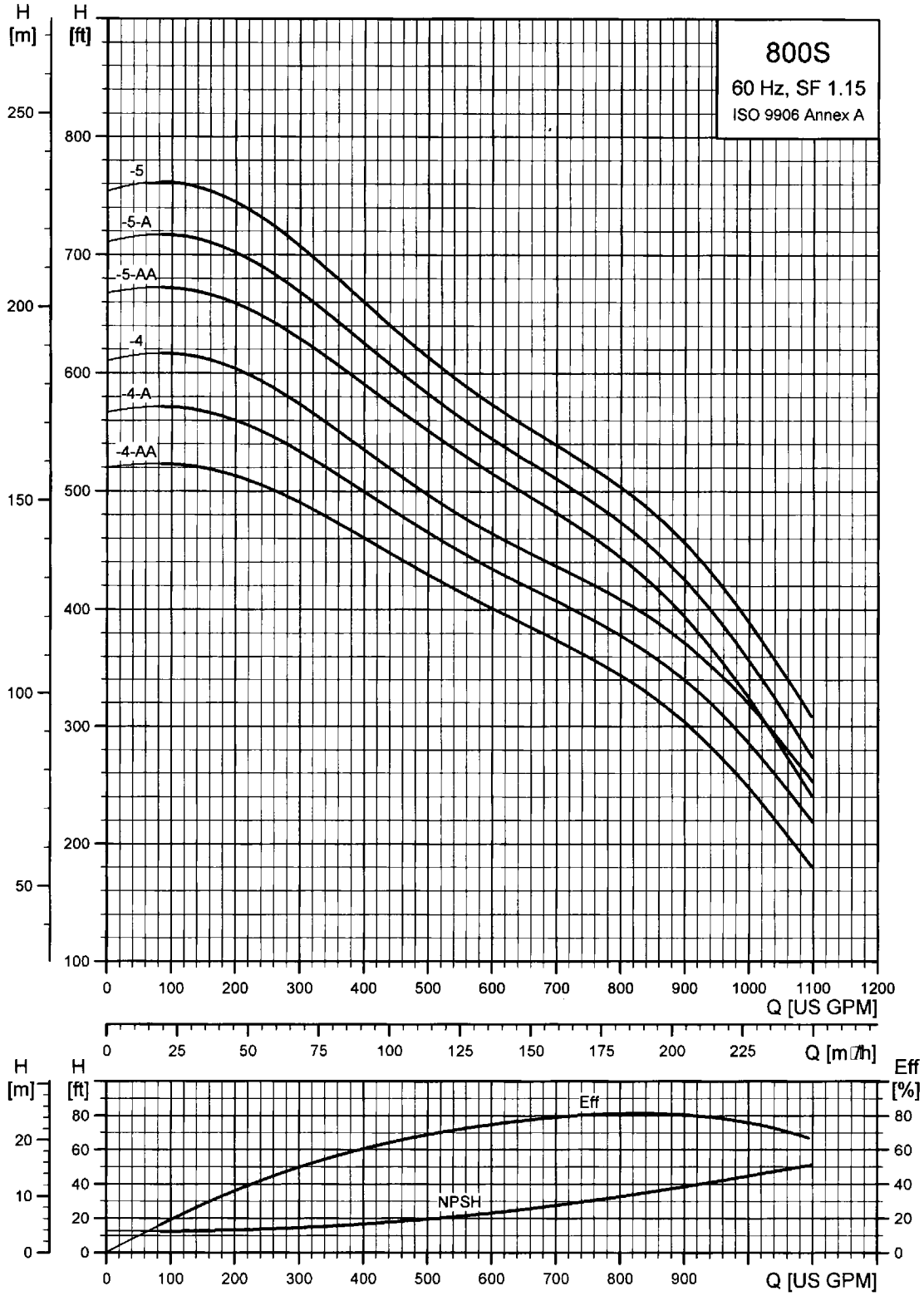
E = Maximum diameter of pump including cable guard and motor.

Notes:
Control box is required for 3-wire, single-phase applications. Data does not include control box.
- ■ MS402 motor.
- ● MS4000 motor.
- ▲ MS6 motor.
- ∧ MMS6000 motor.
- ★ MMS8000 motor.
- ♦ Takes MS6 motor; not available as complete.
- ☼ Takes MMS6000 motor; not available as complete.
- * Takes MMS8000 motor; not available as complete.
- † Takes MMS10000 motor; not available as complete.

800S (800 gpm)

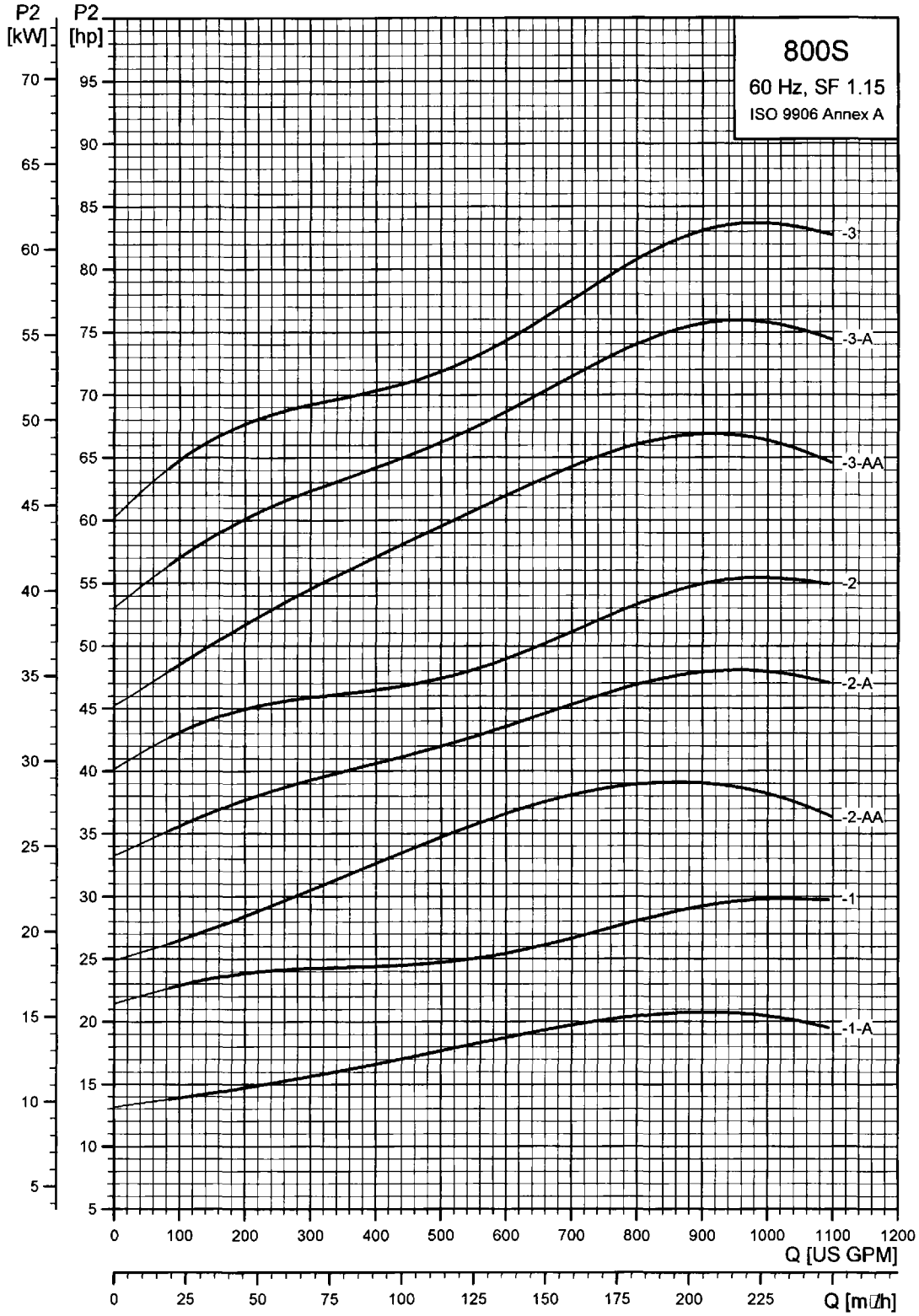

800S
60 Hz, SF 1.15
ISO 9906 Annex A
H [m]
H [ft]
-3
-3-A
-3-AA
-2
-2-A
-2-AA
-1
-1-A
Q [US GPM]
Q [m3/h]
Eff [%]
Eff
NPSH
TM05 0263 0112

800S (800 gpm)



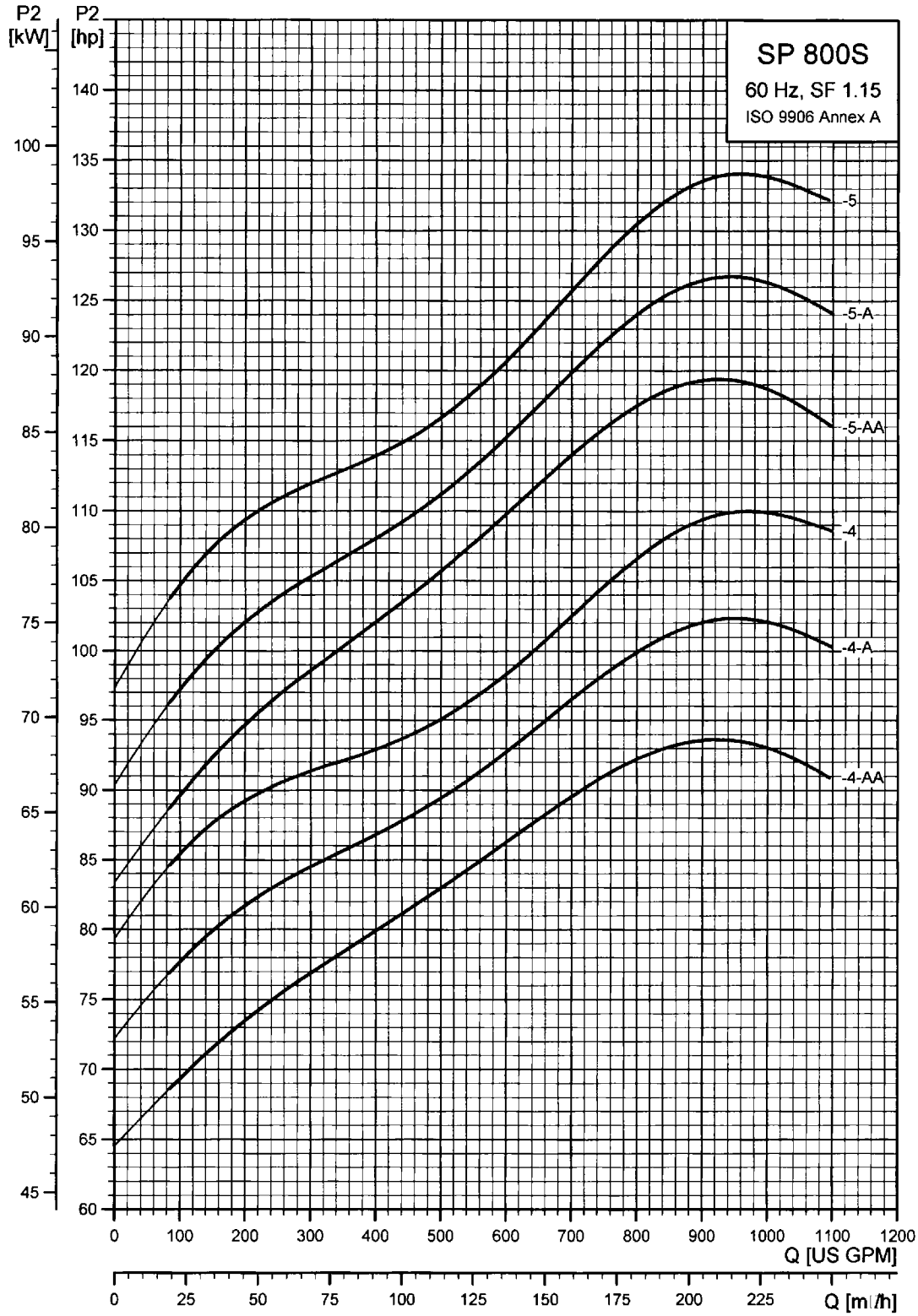
TM05 0264 0112

800S (800 gpm) pump power requirement (P2)



TM05 0265 0112

800S (800 gpm) pump power requirement (P2)

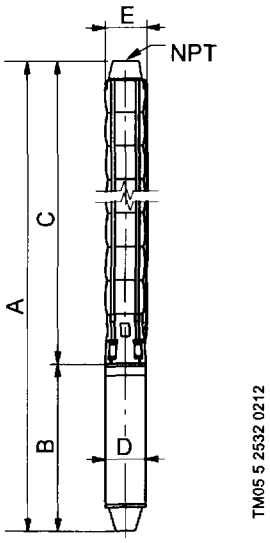


TM05 0266 0811

800S (800 gpm)

Pump model	Nom. head [ft]	Ph	Volts [V]	Motor [Hp]		Dimensions A [in (mm)]	B [in (mm)]	C [in (mm)]	D [in (mm)]	E [in (mm)]	Net weight (complete) [lb]
800S - Motor dia. 6 inch, 3 wire motor, 60 Hz, rated flow 800 gpm (6" NPT)											
800S200-1A	64	3	230	20	▲	56.50 (1435)	30.83 (783)	25.67 (652)	5.63 (143)	8.31 (211)	180.0
		3	460	20	▲	56.50 (1435)	30.83 (783)	25.67 (652)	5.63 (143)	8.31 (211)	180.0
800S300-1	96	3	230	30	▲	61.23 (1555)	35.56 (903)	25.67 (652)	5.63 (143)	8.31 (211)	202.5
		3	460	30	▲	61.23 (1555)	35.56 (903)	25.67 (652)	5.63 (143)	8.31 (211)	202.5
800S400-2AA	131	3	460	35	▲	72.05 (1830)	40.28 (1023)	31.78 (807)	5.63 (143)	8.31 (211)	257.4
800S500-2A	162	3	460	50	☼	88.00 (2235)	56.11 (1425)	31.87 (810)	7.56 (192)	8.39 (213)	363.2
800S500-2	194	3	460	50	☼	88.00 (2235)	56.11 (1425)	31.87 (810)	7.56 (192)	8.39 (213)	363.2
800S600-3AA	197	3	460	60	♦	—	—	37.92 (963)	—	8.39 (213)	—
800S - Motor dia. 8 inch, 3 wire motor, 60 Hz, rated flow 800 gpm (6" NPT)											
800S400-2AA	131	3	460	40	*	75.48 (1917)	43.71 (1110)	31.78 (807)	7.56 (192)	8.39 (213)	409.4
800S500-2A	162	3	460	50	*	77.45 (1967)	45.67 (1160)	31.78 (807)	7.56 (192)	8.39 (213)	431.4
800S500-2	187	3	460	50	*	77.45 (1967)	45.67 (1160)	31.78 (807)	7.56 (192)	8.39 (213)	438.0
800S600-3AA	229	3	460	60	*	87.92 (2233)	50.00 (1270)	37.92 (963)	7.56 (192)	8.39 (213)	490.8
800S750-3A	260	3	460	75	*	91.07 (2313)	53.15 (1350)	37.92 (963)	7.56 (192)	8.39 (213)	523.8
800S750-3	292	3	460	75	*	91.07 (2313)	53.15 (1350)	37.92 (963)	7.56 (192)	8.39 (213)	523.8
800S1000-4AA	327	3	460	100	*	106.62 (2708)	62.60 (1590)	44.02 (1118)	7.56 (192)	8.39 (213)	633.8
800S1000-4A	358	3	460	100	*	106.62 (2708)	62.60 (1590)	44.02 (1118)	7.56 (192)	8.39 (213)	633.8
800S1000-4	389	3	460	100	*	106.62 (2708)	62.60 (1590)	44.02 (1118)	7.56 (192)	8.39 (213)	633.8
800S1250-5AA	426	3	460	125	*	122.21 (3104)	72.05 (1830)	50.16 (1274)	7.56 (192)	8.39 (213)	748.3
800S1250-5A	456	3	460	125	*	122.21 (3104)	72.05 (1830)	50.16 (1274)	7.56 (192)	8.39 (213)	748.3
800S1250-5	487	3	460	125	*	122.21 (3104)	72.05 (1830)	50.16 (1274)	7.56 (192)	8.39 (213)	746.6

800S

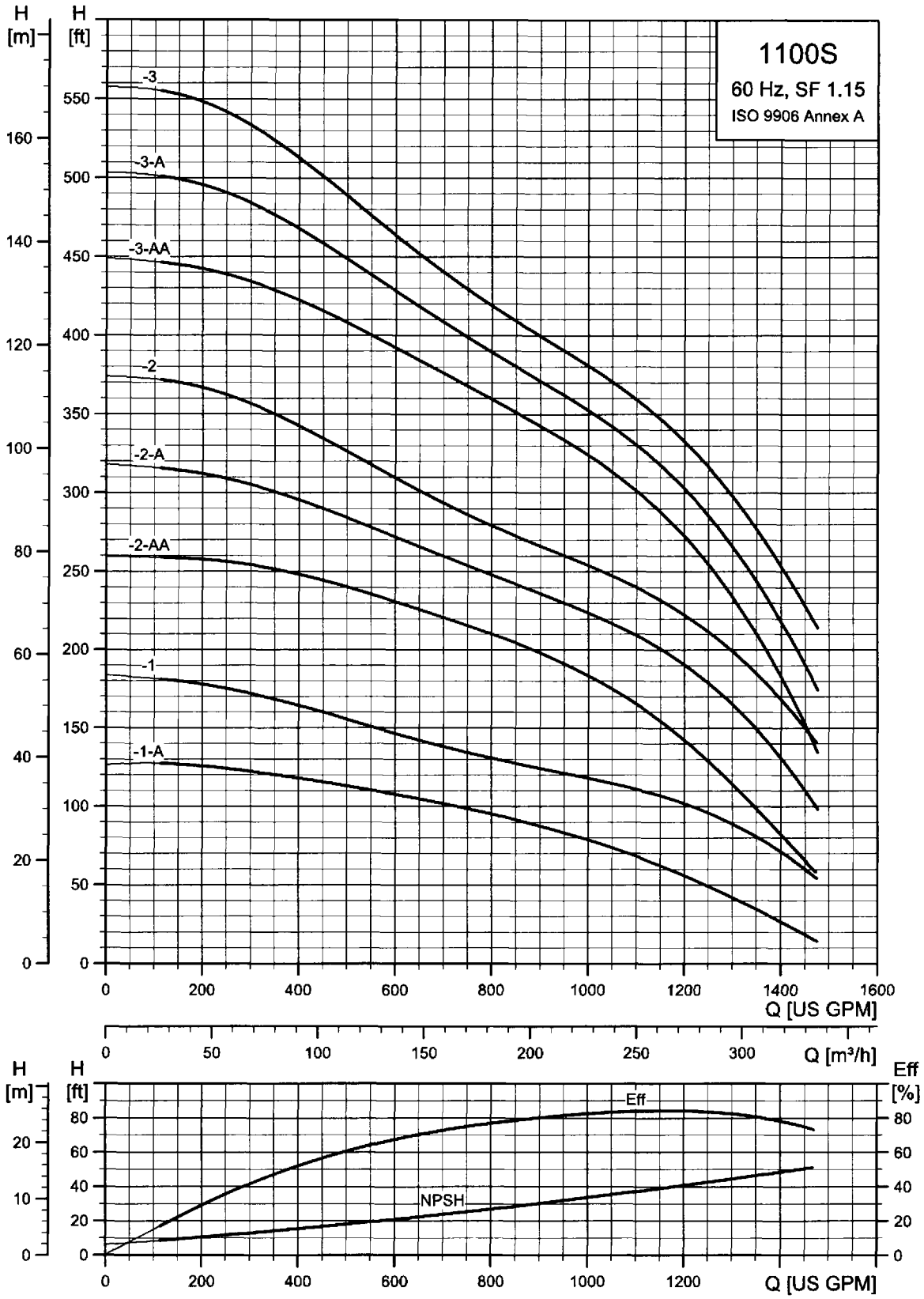


E = Maximum diameter of pump including cable guard and motor.

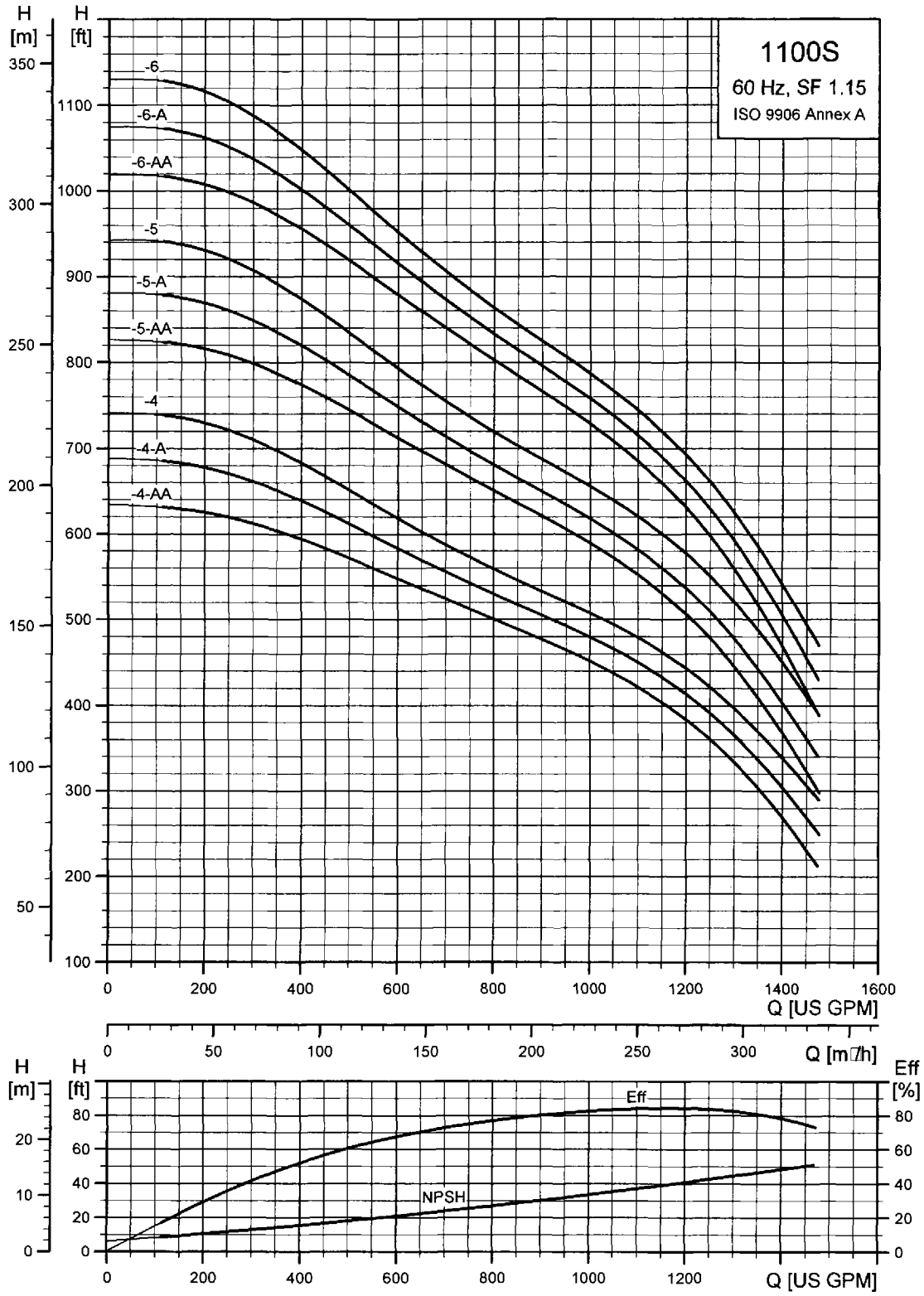
Notes:
Control box is required for 3-wire, single-phase applications. Data does not include control box.

- ■ MS402 motor.
- ● MS4000 motor.
- ▲ MS6 motor.
- ∧ MMS6000 motor.
- ★ MMS8000 motor.
- ♦ Takes MS6 motor; not available as complete.
- ☼ Takes MMS6000 motor; not available as complete.
- * Takes MMS8000 motor; not available as complete.
- † Takes MMS10000 motor; not available as complete.

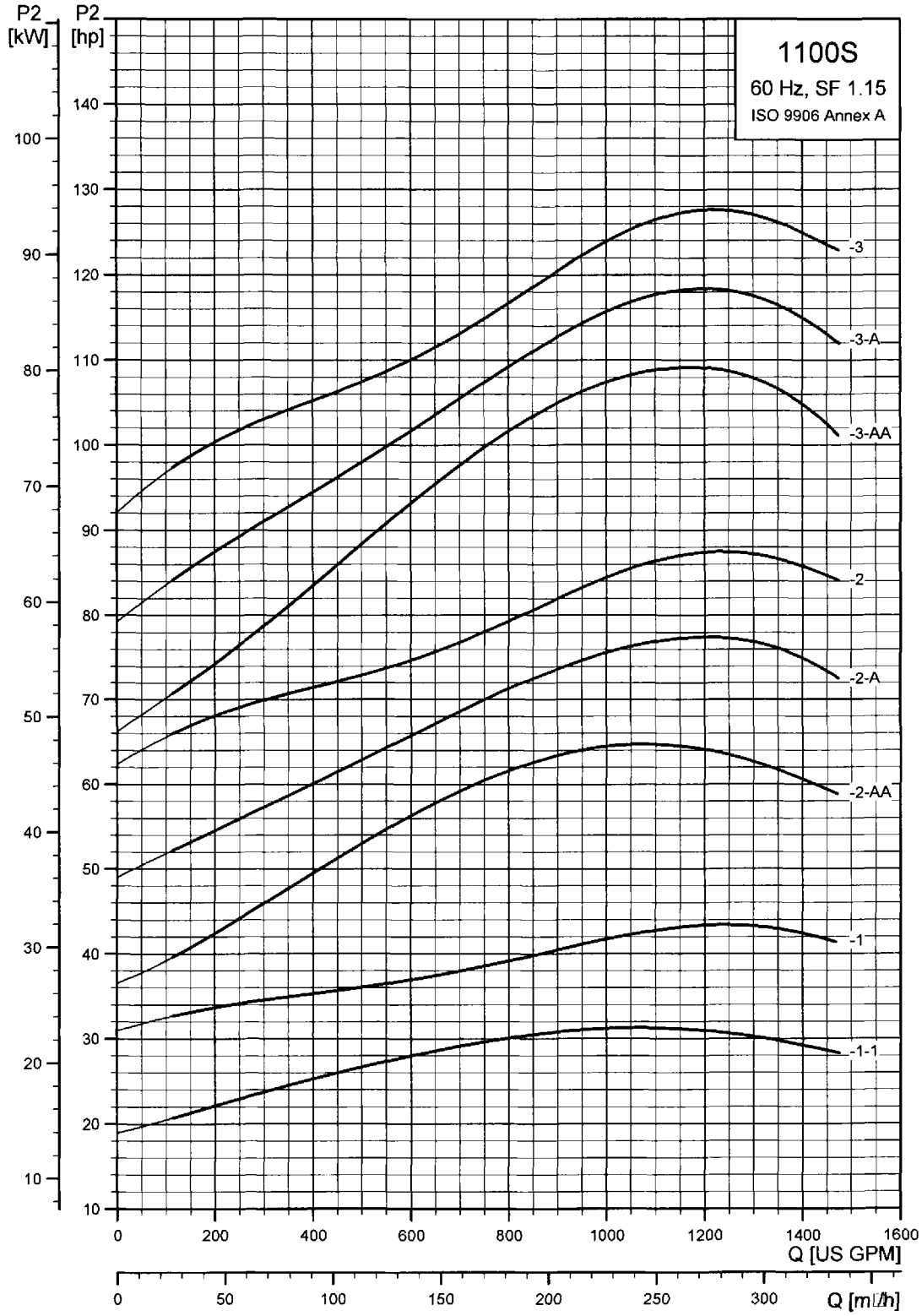
1100S (1100 gpm)



1100S (1100 gpm)

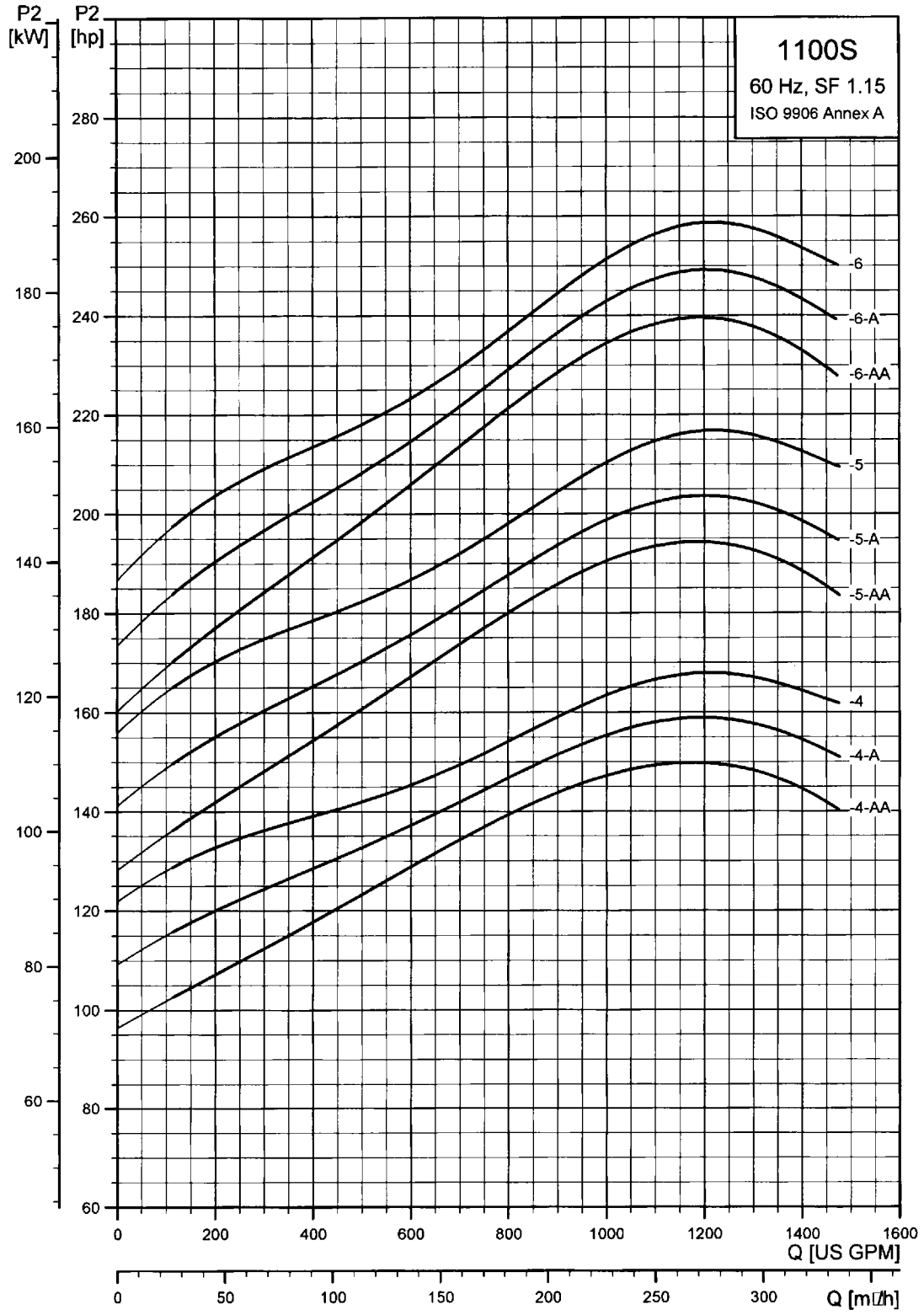


1100S (1100 gpm) pump power requirement (P2)



TM05 0269 0112

1100S (1100 gpm) pump power requirement (P2)



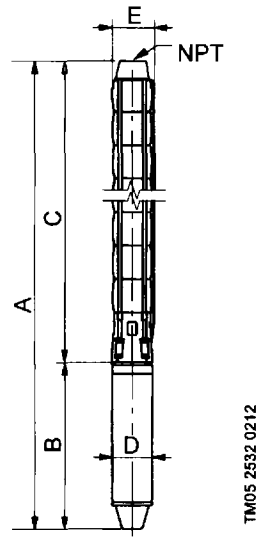
TM05 0270 0112

1100S (1100 gpm)

Pump model	Nom. head [ft]	Ph	Volts [V]	Motor [Hp]		Dimensions A [in (mm)]	B [in (mm)]	C [in (mm)]	D [in (mm)]	E [in (mm)]	Net weight (complete) [lb]
1100S - Motor dia. 6 inch, 3 wire motor, 60 Hz, rated flow 1100 gpm (6" NPT)											
1100S300-1A	67	3	230	30	▲	66.66 (1693)	35.56 (903)	31.11 (790)	5.63 (143)	9.30 (236)	261.0
		3	460	30	▲	66.66 (1693)	35.56 (903)	31.11 (790)	5.63 (143)	9.30 (236)	261.0
1100S400-1	108	3	460	40	▲	71.38 (1813)	40.28 (1023)	31.11 (790)	5.63 (143)	9.30 (236)	290.6
1100S600-2AA	155	3	460	60	♦	—	—	38.04 (966)	—	9.30 (236)	—
1100S - Motor dia. 8 inch, 3 wire motor, 60 Hz, rated flow 1100 gpm (6" NPT)											
1100S400-1	108	3	460	40	*	74.81 (1900)	43.71 (1110)	31.11 (790)	7.56 (192)	9.41 (239)	407.2
1100S600-2AA	155	3	460	60	*	88.04 (2236)	50.00 (1270)	38.04 (966)	7.56 (192)	9.41 (239)	501.8
1100S750-2A	197	3	460	75	*	91.19 (2316)	53.15 (1350)	38.04 (966)	7.56 (192)	9.41 (239)	534.8
1100S1000-2	227	3	460	100	*	100.63 (2556)	62.60 (1590)	38.04 (966)	7.56 (192)	9.41 (239)	633.8
1100S1000-3AA	286	3	460	100	*	107.56 (2732)	62.60 (1590)	44.97 (1142)	7.56 (192)	9.41 (239)	655.9
1100S1250-3A	316	3	460	125	*	117.01 (2972)	72.05 (1830)	44.97 (1142)	7.56 (192)	9.41 (239)	757.1
1100S1250-3	346	3	460	125	*	117.01 (2972)	72.05 (1830)	44.97 (1142)	7.56 (192)	9.41 (239)	757.1
1100S1500-4AA	405	3	460	150	*	133.00 (3378)	81.11 (2060)	51.89 (1318)	7.56 (192)	9.41 (239)	889.1
1100S1500-4A	435	3	460	150	*	133.00 (3378)	81.11 (2060)	51.89 (1318)	7.56 (192)	9.41 (239)	889.1
1100S1500-4	465	3	460	150	*	133.00 (3378)	81.11 (2060)	51.89 (1318)	7.56 (192)	9.41 (239)	889.1
1100S1750-5AA	524	3	460	175	*	—	—	58.82 (1494)	—	9.41 (239)	—
1100S1750-5A	554	3	460	175	*	—	—	58.82 (1494)	—	9.41 (239)	—
1100S2000-5	584	3	460	200	*	—	—	58.82 (1494)	—	9.41 (239)	—
1100S - Motor dia. 10 inch, 3 wire motor, 60 Hz, rated flow 1100 gpm (6" NPT)											
1100S1750-5AA	524	3	460	175	†	132.45 (3364)	73.63 (1870)	58.82 (1494)	9.34 (237)	9.85 (250)	1142.2
1100S1750-5A -1800	554	3	460	175	†	132.45 (3364)	73.63 (1870)	58.82 (1494)	9.34 (237)	9.85 (250)	1137.0
1100S2000-5	584	3	460	200	†	140.32 (3564)	81.5 (2070)	58.82 (1494)	9.34 (237)	9.85 (250)	1285.2
1100S2500-6AA -2600	703	3	460	250	†	160.24 (4070)	94.49 (2400)	65.75 (1670)	9.34 (237)	9.85 (250)	1478.0
1100S2500-6A-2600	673	3	460	250	†	160.24 (4070)	94.49 (2400)	65.75 (1670)	9.34 (237)	9.85 (250)	1483.2
1100S2500-6-2600	703	3	460	250	†	160.24 (4070)	94.49 (2400)	65.75 (1670)	9.34 (237)	9.85 (250)	1483.2

Notes:
Control box is required for 3-wire, single-phase applications. Data does not include control box.
- ■ MS402 motor.
- ● MS4000 motor.
- ▲ MS6 motor.
- ∧ MMS6000 motor.
- ★ MMS8000 motor.
- ♦ Takes MS6 motor; not available as complete.
- ☼ Takes MMS6000 motor; not available as complete.
- * Takes MMS8000 motor; not available as complete.
- † Takes MMS10000 motor; not available as complete.

1100S



E = Maximum diameter of pump including cable guard and motor.

Electrical data

Grundfos submersible pump motors - 60 Hz

Grundfos submersible pump motors - 60 Hz												
Hp	Ph	Volt [V]	S.F.	Circuit breaker or fuses		Amperage		Full load		Max. thrust [lbs]	Nameplate number	Product number
				Std.	Delay	Start [A]	Max. [A]	Eff. [%]	Power factor [%]			
4-inch, single-phase, 2-wire motors (control box not required)												
.5	1	115	1.60	35	15	55.0	12.0	62	76	900	79922102	96465574
.5	1	230	1.60	15	7	34.5	6.0	62	76	750	79952102	96465616
.75			1.50	20	9	40.5	8.4	62	75	750	79952103	96465618
1			1.40	25	12	48.4	9.8	63	82	750	79952104	96465620
1.5			1.30	35	15	62.0	13.1	64	85	750	79952105	96465622
4-inch, single-phase, 3-wire motors												
.5	1	115	1.60	35	15	42.5	12.0	61	76	900	79423102	96023039
.5	1	230	1.60	15	7	21.5	6.0	62	76	750	79453102	96465606
.75			1.50	20	9	31.4	8.4	62	75	750	79453103	96465608
1			1.40	25	12	37.0	9.8	63	82	750	79453104	9646510
1.5			1.30	35	15	45.9	11.6	69	89	750	79453105	96465612
4-inch, three-phase, 3-wire motors												
1.5	3	230	1.30	15	8	40.3	7.3	75	72	750	79302005	96465629
		460	1.30	10	4	20.1	3.7	75	72	750	79362005	96465651
		575	1.30	10	4	16.1	2.9	75	72	750	79392005	96785912
2	3	230	1.25	20	10	48	8.7	76	75	750	79302006	96465630
		460	1.25	10	5	24	4.4	76	75	750	79362006	96465652
		575	1.25	10	4	19.2	3.5	76	75	750	79392006	96785917
3	3	230	1.15	30	15	56	12.2	77	75	1000	79304507	96405801
		460	1.15	15	7	28	6.1	77	75	1000	79354507	96405810
		575	1.15	15	6	22	4.8	77	75	1000	79394507	96405815
5	3	230	1.15	40	25	108	19.8	80	82	1000	79304509	96405802
		460	1.15	20	12	54	9.9	80	82	1000	79354509	96405811
		575	1.15	15	9	54	7.9	80	82	1000	79394509	96405816
7.5	3	230	1.15	60	30	130	25.0	81	82	1000	79305511	96405805
		460	1.15	35	15	67	13.2	81	82	1000	79355511	96405814
		575	1.15	30	15	67	10.6	81	82	1000	79395511	96405819
6-inch, three-phase, 3-wire motors												
7.5	3	230	1.15	60	35	119	26.4	80.5	76	1000	78305511	96405781
		460	1.15	30	15	59	13.2	80.5	76	1000	78355511	96405794
10	3	230	1.15	80	45	156	34.0	82.5	79	1000	78305512	96405782
		460	1.15	40	20	78	17.0	82.0	79	1000	78355512	96405795
15	3	230	1.15	150	80	343	66.0	84.0	81	4400	78305516	96405784
		460	1.15	60	30	115	24.5	82.5	82	4400	78305514	96405796
20	3	230	1.15	150	80	343	66.0	84	81	4400	78305516	96405784
		460	1.15	80	40	172	33.0	84	82	4400	78355516	96405797
25	3	460	1.15	100	50	217	41.0	84.5	80	4400	78355517	96405798
30	3	460	1.15	110	60	237	46.5	85	83	4400	78355518	96405799
40	3	460	1.15	150	80	320	64.0	85	82	4400	78355520	96405800
50	3	460	1.15	225	125	470	68.7	84	83	13000	96476890	96023200
8-inch, three-phase, 3-wire motors												
40	3	460	1.15	175	100	380	55.7	83	85	13000	96530180	96023204
50	3	460	1.15	225	125	550	67.8	84	85	13000	96530182	96023205
60	3	460	1.15	250	150	640	80.4	86	85	13000	96476891	96023206
75	3	460	1.15	300	175	580	97.4	86	86	13000	96476892	96023207
100	3	460	1.15	400	225	570	130.4	87	86	13000	96476893	96023208
125	3	460	1.15	500	300	600	160.0	87	87	13000	96476894	96023209
150	3	460	1.15	600	350	580	191.3	86	87	13000	96511375	96023210
10-inch, three-phase, 3-wire motors												
175	3	460	1.15	700	400	570	230.4	88	85	13000	96521619	96937300
200	3	460	1.15	800	500	620	265.2	87	82	13000	96540302	96937302
250	3	460	1.15	1100	600	610	352.2	87	79	13000	96463669	96937316

Other motor manufacturers

- Hitachi motors: Refer to the Hitachi submersible motors application maintenance manual.
- Franklin motors: Refer to the Franklin submersible motors application maintenance manual.

7. Accessories

MP 204

The MP 204 is an electronic motor protector, designed for the protection of an asynchronous motor or a pump.

The motor protector consists of:

- a cabinet incorporating transformers and electronics
- a control panel with operating buttons and display for reading of data.

The MP 204 operates with two sets of limits:

- a set of warning limits and
- a set of trip limits.

If one or more of the warning limits are exceeded, the motor continues to run, but the warnings will appear in the MP 204 display.

Some values only have a warning limit.

The warning can also be read out by means of the Grundfos R100 remote control.

If one of the trip limits is exceeded, the trip relay will stop the motor. At the same time, the signal relay is operating to indicate that the limit has been exceeded.

Applications

The MP 204 can be used as a stand-alone motor protector.

The MP 204 can be monitored via a Grundfos GENIbus.

The power supply to the MP 204 is in parallel with the supply to the motor. Motor currents up to 120 A are passed directly through the MP 204. The MP 204 protects the motor primarily by measuring the motor current by means of a true RMS measurement. The MP 204 disconnects the contactor if, for example, the current exceeds the preset value.

Secondarily, the motor is protected via temperature measuring by a Tempcon sensor, a Pt100/Pt1000 sensor and a PTC sensor/thermal switch.

The MP 204 is designed for single- and three-phase motors. In single-phase motors, the starting and run capacitors are also measured. Cos □ is measured in both single- and three-phase systems.

Benefits

The MP 204 offers these benefits:

- Suitable for both single- and three-phase motors
- Dry-running protection
- Overload protection
- Very high accuracy
- Made for submersible pumps.

Many monitoring options

The MP 204 monitors the following parameters:

- Insulation resistance before start-up
- Temperature (Tempcon, Pt sensor and PTC/thermal switch)
- Overload/underload
- Overvoltage/undervoltage
- Phase sequence
- Phase failure
- Power factor
- Power consumption
- Harmonic distortion
- Operating hours and number of starts.

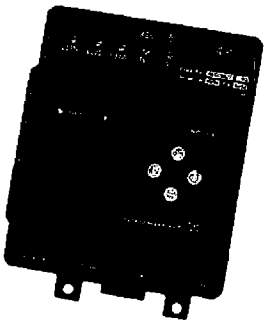


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Fig. 21 MP 204

Five sizes of single-turn transformers, 120-999 A.
Note: Monitoring of motor temperature is not possible when single-turn transformers are used.

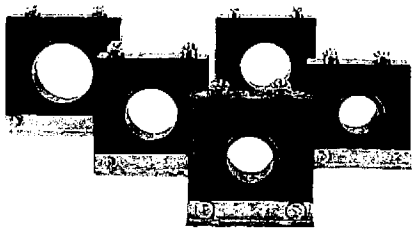

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Fig. 22 Single-turn transformers

Product numbers

Product	Product number
MP 204	96079927
R100	625333

Functions

- Phase-sequence monitoring
- Indication of current or temperature (user selection)
- Indication of temperature in °F or °C (user selection)
- 4-digit, 7-segment display
- Setting and status reading with the R100
- Setting and status reading via the GENIbus.

Tripping conditions

- Overload
- Underload (dry running)
- Temperature (Tempcon sensor, PTC/thermal switch and Pt sensor)
- Phase failure
- Phase sequence
- Overvoltage
- Undervoltage
- Power factor (cos □)
- Current unbalance.

Warnings

- Overload
- Underload
- Temperature (Tempcon and Pt sensor)
- Overvoltage
- Undervoltage
- Power factor (cos □)
  Note: In connection with single- and three-phase connection.
- Run capacitor (single-phase operation)
- Starting capacitor (single-phase operation)
- Loss of communication in network
- Harmonic distortion.

Learning function

- Phase sequence (three-phase operation)
- Run capacitor (single-phase operation)
- Starting capacitor (single-phase operation)
- Identification and measurement of Pt100/Pt1000 sensor circuit.

External current transformers

When fitted with external current transformers, the MP 204 unit can handle currents from 120 to 999 A. Grundfos can supply approved current transformers from stock (200/5A, 300/5A, 500/5A, 750/5A, 1000/5A).

Remote control R100

The R100 remote control from Grundfos allows for wireless infrared remote control of your MP 204 unit.

With the R100, you get access to a full range of options such as factory setting adjustment, service and fault finding.

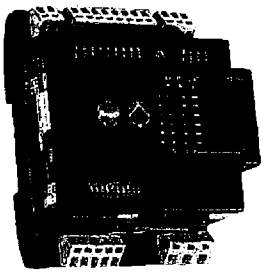
Ready for bus communication

The MP 204 allows for monitoring and communication via GENIbus — a Grundfos-designed bus for exchange of pump data, alarms, status information, and setpoints. This enables users to connect the MP 204 to, for instance, SCADA systems.

Technical data - MP 204

Enclosure class	IP 20
Ambient temperature	–4 °F to +140 °F (–20 °C to +60 °C)
Relative air humidity	99%
Voltage range	100-480 VAC
Current range	3-999 A
Frequency	50 to 60 Hz
IEC trip class	1-45
Special Grundfos trip class	0.1 to 30 s
Voltage variation	–25 %/+15 % of nominal voltage
Approvals	EN 60947, EN 60335, UL/CSA 508
Marking	CE, cUL, C-tick
Consumption	Max. 5 W
Plastic type	Black PC / ABS

	Measuring range	Accuracy	Resolution
Current without external current transformers	3-120 A	±1 %	0.1 A
Current with external current transformers	120-999 A	±1 %	1 A
Phase-to-phase voltage	80-610 VAC	±1 %	1 V
Frequency	47-63 Hz	±1 %	0.5 Hz
Power	0-1 MW	±2 %	1 W
Power factor	0-0.99	±2 %	0.01
Energy consumption	$0\text{-}4 \times 10^9$ kWh	±5 %	1 kWh

IO 112	Description	Product number
	The IO 112 is a measuring module and a 1-channel protection unit for use in connection with the MP 204 motor protection unit. The module can be used for protection of pump against other factors than the electrical conditions, for instance dry-running. It can also be used as a stand-alone protection module. The IO 112 interface has three inputs for measured values one potentiometer for setting of limits indicator lights indicating the • measured value of the input • value of the limit set • alarm source • pump status. **Electrical data:** • Supply voltage: 24 VAC ±10% 50/60 Hz or 24 VDC ±10% • Supply current: Min. 2.4 A; max. 8 A • Power consumption:Max. 5 W Ambient temperature: –13 °F to+149 °F (–25 °C to +65 °C) • Enclosure class: IP 20	96651601

Control functions

This table describes the protection provided by MP 204.

Control parameters	Function	Problem	Advantages
Temperature	**MS** The motor temperature is measured by means of the built-in Tempcon temperature transmitter and a signal is sent to MP 204 via the phase leads. In MP 204 the measured temperature is compared with the factory-set value (167 °F (75 °C)). **MMS** The motor temperature is measured by means of the Pt100. The signal is sent to the MP 204 where the measured temperature is compared with the factory-set value. Temperature protection requires a submersible motor with a Pt100. The motor temperature must be monitored during frequency converter operation.	Overload, frequent starts/stops, operation against blocked discharge pipe, insufficient flow velocity past the motor.	Longer motor life, safe operating conditions, service indication.
Overvoltage/ undervoltage	If the set trip value is exceeded, the motor will stop.	The installation is close to a transformer. The mains do not absorb load variations.	Important installation parameter, possibility of improving operating conditions.
Overload	The motor power input is measured on each of the three phases. The registered power input is an average of these three values. If the factory-set value is exceeded, the motor will stop.	Incorrect sizing of pump/motor, voltage supply failure, defective cable, blocking, wear or corrosion.	Longer pump life, safe operating conditions, service indication.
Underload (dry running)	The motor power input is measured on each of the three phases. The registered power input is an average of these three values. If the average value is lower than the factory-set value, the motor will stop.	Pump exposed to dry running or underload, for example caused by wear.	Traditional dry-running protection is no longer necessary, no extra cables.
Current unbalance	The power input of the motor is measured on each of the three phases.	Mains load is uneven, incipient motor defect, phase voltages diverging.	Motor protection against overload, service indication.
Phase sequence	MP 204 and motor are installed so that the phase sequence corresponds to correct direction of rotation. MP 204 monitors changes in the phase sequence.	Two phases are wrongly connected.	Ensures correct pump performance.
Phase failure	MP 204 checks the phases connected, phase failure will cause an alarm.	Phase failure	Indication of phase failure, and alarm.

R100 menus

0. GENERAL

See the operating instructions for the R100.

1. OPERATION

- Operating mode
- Actual trip
- Actual warning 1
- Actual warning 2
- Alarm log 1
- Alarm log 2
- Alarm log 3
- Alarm log 4
- Alarm log 5.

2. STATUS

Display of

- Supply overview
- Average current
- Average voltage
- Tempcon sensor
- Pt100/Pt1000 sensor
- *Power input and energy consumption* (described in the following)
- Energy trip counter
- Phase sequence
- Current unbalance
- Operating hours and number of starts
- Trip counter of hours and starts
- Starting capacitor
- Run capacitor
- Insulation resistance
- Cos □
- Harmonic distortion.

3. LIMITS

Display and setting of warning and trip limits.

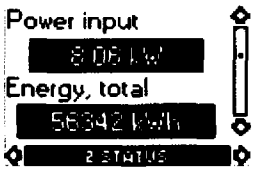
- Tempcon sensor
- Pt sensor
- Tripping current
- Current warning
- Nominal voltage
- Voltage limits
- Current unbalance
- Starting capacitor
- Run capacitor
- Insulation resistance
- Cos □ trip
- Cos □ warning.

4. INSTALLATION

Setting and display of

- Supply mains
- Trip class (described in the following)
- Trip delay
- External current transformers
- Power-on delay
- Restarting (described in the following)
- Automatic restarting (described in the following)
- Tempcon sensor
- Pt sensor
- Insulation resistance measurement
- PTC/thermal switch
- Resetting of trip counters
- Service interval
- Number of automatic restarts
- Units/display
- MP 204 display
- GENIbus ID number
- Learning function.

Power input and energy consumption



Actual input power and motor energy consumption.

The energy consumption is an accumulated value which cannot be reset.

The power is calculated like this:

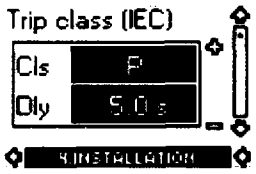
$$U_{average} = \frac{U_{L1-L2} + U_{L2-L3} + U_{L3-L1}}{3} \; [V]$$

$$I_{average} = \frac{I_{L1} + I_{L2} + I_{L3}}{3} \; [A]$$

$$\cos\varphi_{average} = \frac{\cos\varphi_{L1} + \cos\varphi_{L2} + \cos\varphi_{L3}}{3} \; [-]$$

$$P = [U_{average}] \cdot [I_{average}] \cdot \sqrt{3} \cdot \cos\varphi_{average} \; [W]$$

Trip class



Line 1: Select IEC trip class (1 to 45).

If manual indication of trip delay in the case of overload is required, select trip class "P".

Factory setting:

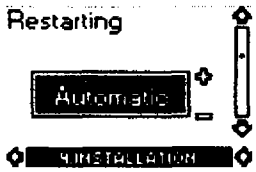
- Cls (trip class): P.

Line 2: Select trip delay.

Factory setting:

- Dly (trip delay): 10 s.

Restarting



Set whether restarting after tripping is to be

- *Automatic* (factory setting)
- *Manual.*

Setting of time, see section "Automatic restarting".

Automatic restarting

Set the time after which the MP 204 is to attempt automatic restarting of motor after cut-out.

The time runs from the moment when the value which triggered the fault has returned to normal.

Factory setting:

- 300 s.

G100 gateway for communication with Grundfos products

The G100 offers a wide selection of options for integration of Grundfos products provided with GENIbus interface into main control and monitoring systems.

The G100 enables a pump installation to meet future demands for optimum pump operation in terms of reliability, operating costs, centralization and automation.

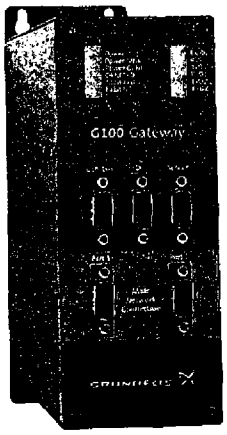


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Fig. 23 G100

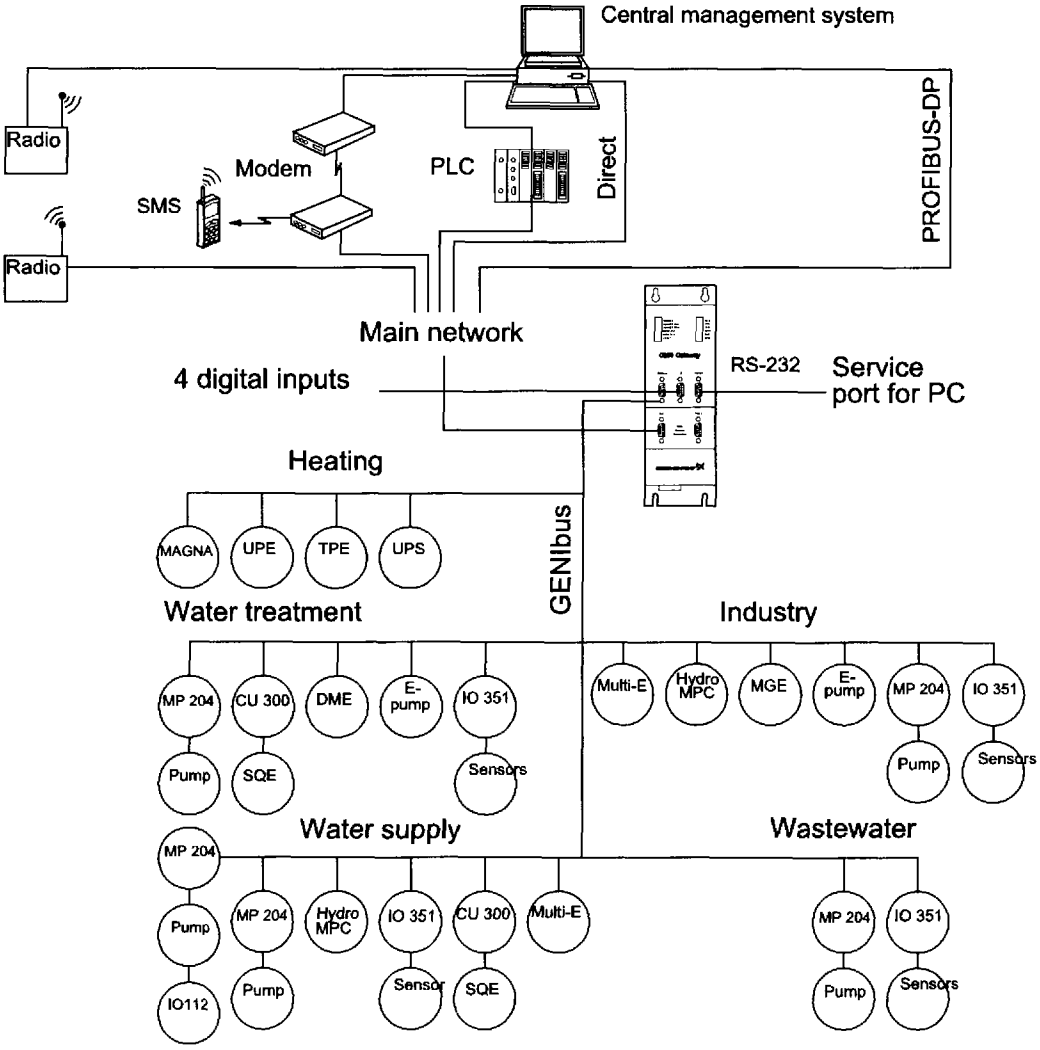

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Fig. 24 Examples of G100 applications

Product description

The G100 Gateway enables communication of operating data, such as measured values and setpoints, between Grundfos products with GENIbus interface and a main network for control and monitoring.

As indicated in the illustration on page 92, the G100 is suitable for use in applications such as water supply, water treatment, wastewater, building automation and industry.

Common to above applications is that downtime is usually costly, and extra investments are therefore often made to achieve maximum reliability by monitoring selected operating variables.

The day-to-day operation, such as starting and stopping of pumps and changing of setpoints, can also be effected from the main system by communication with the G100. In addition, the G100 can be set up to send event-controlled status indications such as alarms via the SMS to mobile phones, and to make automatic alarm call-backs to a central management system.

Data logging

Besides the possibility of data communication, the G100 offers logging of up to 350,000 time-stamped data. The logged data can be transmitted to the main system or a PC for further analysis in a spreadsheet or similar program.

For the data logging, the "PC Tool G100 Data Log" software tool is used. The tool is part of the PC Tool G100 package, which is supplied with the G100.

Other features

- Four digital inputs.
- Stop of all pumps in case of failing communication with the management system (optional).
- Access code for modem communication (optional).
- Alarm log.

Installation

Installation of the G100 is effected by the system integrator. The G100 is connected to the GENIbus as well as to the main network. All units on the GENIbus can thus be controlled from a central management system on the main network.

The "G100 Support Files" CD-ROM supplied with the G100 contains examples of programs to be used when the G100 is connected to the various main network systems. Included is also a description of the data points available in Grundfos products with GENIbus interface.

The "PC Tool G100" software tool included can be used for the installation and use of G100.

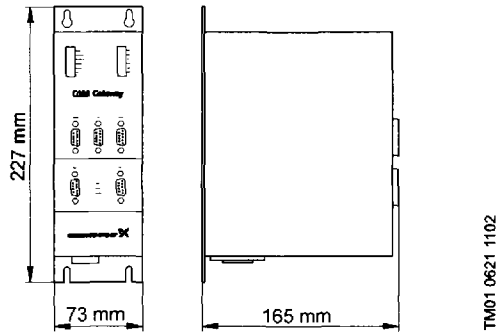


Fig. 25 Dimensional sketch

Technical data

Overview of protocols

Main system	Software protocol
PROFIBUS-DP	DP
Radio	Satt Control COMLI/Modbus
Modem	Satt Control COMLI/Modbus
PLC	Satt Control COMLI/Modbus
GSM mobile phone	SMS, UCP

Other possible connections

GENIbus RS-485:	Connection of up to 32 units.
Service port RS-232:	For direct connection to a PC or via radio modem.
Digital inputs:	4.
Voltage supply:	1 x 110-240 V, 50/60 Hz.
Ambient temperature:	In operation: –4 °F to +140 °F (–20 °C to +60 °C).
Enclosure class:	IP 20.
Weight:	1.8 kg.

Accessories

- PC Tool G100 package (supplied with the product)
- G100 Support Files CD-ROM (supplied with product)

Product numbers

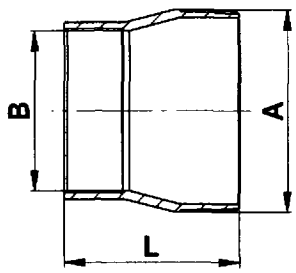
Product	Product number
G100 with Profibus-DP expansion board*	96411135
G100 with Radio/Modem/PLC expansion board*	96411136
G100 Basic Version*	96411137
PC Tool G100 package	96415783

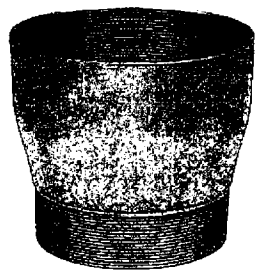
* CD-ROM with G100 Support Files included.

Connecting pieces

The tables below show the range of connecting pieces for connection of thread-to-flange and thread-to-thread.

Thread-to- thread





TM01 2397 1698 - GrA2555

Fig. 26 Dimensional sketch and photo of connecting piece thread-to-thread

Type	Connecting piece	Dimensions			Product number	
		Thread-to-thread		L [in (mm)]		
		A	B		304 stainless steel	316 stainless steel
385S 475S	NPT 5□ NPT 4	NPT 5	NPT 4	4.76 (121)	190064	190586
	NPT 5□ NPT 6	NPT 5	NPT 6	5.91 (150)	190070	190592
625S 800S 1100S	NPT 6□ NPT 5	NPT 6	NPT 5	5.91 (150)	200135	200645

Zinc anodes

Application

Cathodic protection by means of zinc can be used for corrosion protection of SP pumps in chloride-containing liquids such as brackish water and seawater.

Sacrificial anodes are placed on the outside of the pump and motor as protection against corrosion.

The number of anodes required depends on the pump and motor in question.

Please contact Grundfos for further details.

Liquid temperatures

- Seawater:
  Up to 95 °F (35 °C).
- Brackish water (min. 1500 ppm (g/m^3) chloride):
  Up to 95 °F (35 °C).

Anode life

The zinc anodes have a life of one to four years, depending on operating conditions (temperature, flow and chloride content).

Product numbers of zinc anodes

Zinc anodes for pumps										
	Used for pump type									
Product number	SP 5S to 75S	85S	150S	230S	300S	385S	475S	625S	800S	1100S
96421444	□	-	-	-	-	-	-	-	-	-
96421445	-	□	□	□	□	-	-	-	-	-
96421447	-	-	-	-	-	□	□	-	-	-
96421448	-	-	-	-	-	-	□	-	-	-
96421449	-	-	-	-	-	-	-	□	-	-
96421450	-	-	-	-	-	-	-	□	□	□

Zinc anodes for motors			
4" motors	6" motors	8" motors	10" motors
96421444	96421446	96421450	96564808

SA-SPM 5 control boxes

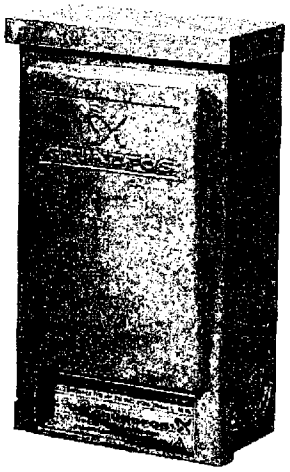
Application

SA-SPM 5 control boxes are used as starting units for single-phase, 3-wire motors, types MS 402B with power input lower than or equal to 1.5 hp (1.1 kW).

SA-SPM 5 is available in two versions, standard and DeLuxe. The standard version incorporates a motor -protective circuit breaker and thus protects the motor against overload. The DeLuxe version is identical to the standard version with the following addition a motor contactor is included for connection and disconnection of the power supply.

Technical data

Enclosure class:	IP 42.
Ambient temperature:	–4 °F to +140 °F (–20 °C to +60 °C).
Relative humidity:	Maximum 95 %, normal non-aggressive atmosphere.



TM03 8150 0607

Fig. 27 SA-SPM 5 control box

Product numbers

Product	Description					Product number
	1 x 220-230 V	1.5 hp	2.0 hp	3.0 hp	5.0 hp	
SA-SPM 5 (Standard version)	□	□	-	-	-	91126212
SA-SPM 5 (DeLuxe version)	□	□	-	-	-	91126213
SA-SPM 5 (Standard version)	□	-	□	-	-	91126214
SA-SPM 5 (DeLuxe version)	□	-	□	-	-	91126215
SA-SPM 5 (Standard version)	□	-	-	□	-	91126216
SA-SPM 5 (DeLuxe version)	□	-	-	□	-	91126217
SA-SPM 5 (Standard version)	□	-	-	-	□	91126218
SA-SPM 5 (DeLuxe version)	□	-	-	-	□	91126219

Pt100

The Pt100 sensor offers these features:

- Continuous monitoring of the motor temperature
- Protection against too high motor temperature.

Protecting the motor against too high motor temperature is the simplest and cheapest way of avoiding that motor lifetime is reduced. Pt100 ensures that operating conditions are not exceeded and indicates when it is time for service of the motor.

Monitoring and protection by means of Pt100 require the following parts:

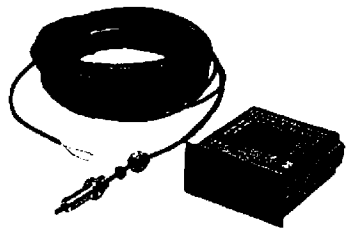
- Pt100 sensor
- Relay, type PR 5714
- Cable.

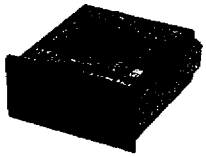
The PR 5714 relay is fitted with a Pt100 module. For both relays the following temperature limits are preset on delivery:

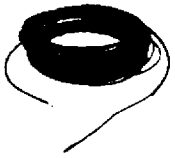
- +60 °C (+140 °F) warning limit
- +75 °C (+167 °F) stop limit.

Technical data

	Relay type
	PR 5714
Enclosure class	IP 65 (mounted in a control panel)
Ambient temperature	–4 °F to +140 °F (–20 °C to +60 °C)
Relative humidity	95 % (condensating)
Voltage variation	• 1 x 24-230 VAC ±10 %, 50 - 60 Hz. • 24-250 VDC ±20 %.
Approvals	UL, DNV
Mark	CE

Pt100 sensor with/without PR 5714 relay and cable	Cable length [ft (m)]	PR 5714	Product number		
			MS6	MMS 6000, MMS 8000	MMS 10000, MMS 12000
	65.6 (20)	Yes	96408953	96494596	96437287
	131.2 (40)	Yes	96408681	96494597	96437288
	196.9 (60)	Yes	96408954	96494598	96437289
	262.5 (80)	Yes	96408955	96494599	96437290
	328.1 (100)	Yes	96408956	96494610	96437291
	65.6 (20)	No	96658626	96658629	96658633
	131.2 (40)	No	96658627	96658630	96658634
	196.9 (60)	No	96658628	96658631	96658635
	262.5 (80)	No	96658637	96658632	96658636
	328.1 (100)	No	96658638	96658639	96658640

PR 5714 relay	Voltage	Product number
	24-230 VAC, 50/60 Hz / 24-250 VDC	96621274

Pt100 sensor including cable	Cable length [ft (m)]	Product number	
		MS6, MMS 6000, MMS 8000	MMS 10000 MMS 12000
	65.6 (20)	96408957	96437784
	131.2 (40)	96408684	96437785
	196.9 (60)	96408958	96437786
	262.5 (80)	96408959	96437787
	328.1 (100)	96408960	96437788

Staybolts for Pt100	Description	Product number
	Bolt KIT for Pt100 (for MS6)	96611899

8. Energy consumption

Energy consumption of submersible pumps

The percentage distribution of service life costs of a submersible pump for water supply is:

5 % initial costs (pump)
85 % operating costs / energy consumption
10 % maintenance costs.

It is obvious that the highest savings can be achieved within energy consumption!

The annual energy consumption, E, of a submersible pump can be calculated as follows:

E = c x h x P_1 (EURO)

c = specific energy price (EURO/kWh)

h = operating hours/year (hours)

P_1 = power input of the submersible pump (kW).

Example: Calculation of the annual energy consumption of the submersible pump, type 625S-3.

625S-3 with MS 8000, 45 kW, 3 x 460 V, 60 Hz.

Duty point:
Flow rate: Q = 120 m^3/h

Total head: H = 102 m

Specific energy price: c = EURO 0.1/kWh
(consisting of day and night rate)

Operating hours/year: h = 3200.

$$P_1 = \frac{Q \square H \square \square}{367 \square \square_{pump} \square \square_{motor}} \text{ in kW}$$

Q = m^3/h

H = m

Density □ = kg/dm^3 (assumed 1)

367 = conversion factor

$\square_{motor}$ = (example 84.5 %, in equation 0.845)

$\square_{pump}$ = (not to be confused with the stage efficiency curve).

By showing the P_2/Q curve we make it easier for you to calculate the energy consumption.

$$P_1 = \frac{P_2}{\square_{motor}}$$

P_2 = 26 kW (power requirement of 625S-3 pump at 20 m^3/h, from curve P_2 / Q on page 72).

Calculation of motor efficiency at duty point
As standard the SP 625S-3 is equipped with a 45 kW MS6 motor.

At duty point (Q = 120 m^3/h) the pump requires 44 kW, thus:

a motor load of 87 % (44 kW / 45 kW) and a power reserve of 2 %.

From the table on page 72 the motor efficiency can be read as:

84.6 % at a load of 75 %. ($\square_{75\,\%}$)
85.6 % at a load of 100 %. ($\square_{100\,\%}$)
The interpolated value in this example is
$\square_{motor}$ = 85.1 %, $\square_{motor}$ = 0.851.

$$P_1 = \frac{44}{0.851} = 51.7 \text{ kW}$$

E = 0.1 EURO/kWh x 3200 h x 51.7 kW.
The annual energy costs amount to EURO 16544.

The pay-off time, A, (months) is calculated as follows:

$$A = \frac{\text{Purchase price of energy - efficiency pump}}{\text{Energy savings/year}} \square 12$$

Cable sizing
In order to obtain an economical duty of the pump the voltage drop should be low.

Today large water works already size cables for a maximum voltage drop of 1 %).

The hydraulic resistance in the discharge pipe should be as low as possible.

9. Cables

Grundfos offers submersible drop cables for all applications: 3-core cable, 4-core cable, single leads.

Cables for Grundfos 4" submersible motors are available with or without plugs. The submersible drop cable is chosen according to application and type of installation.

Standard version: Max. liquid temperature +140 °F +60 °C).

Hot water version: Max. liquid temperature +158 °F (+70 °C), for short periods up to 194 °F (+90 °C) (for MS only).

Tables indicating cable dimension in borehole

The tables indicate the maximum length of drop cables in meters from motor starter to pump at direct-on-line starting at different cable dimensions.

If star/delta starting is used the current will be reduced by $\sqrt{3}$ (I x 0.58), meaning that the cable length may be $\sqrt{3}$ longer (L x 1.73) than indicated in the tables.

If for example the operating current is 10 % lower than the full-load current, the cable may be 10 % longer than indicated in the tables.

The calculation of the cable length is based on a maximum voltage drop of 1 % to 3 % of the rated voltage and a water temperature of maximum +86 °F (30 °C).

In order to minimize operating losses the cable cross section may be increased compared to what is indicated in the tables. This is economical only if the borehole provides the necessary space, and if the operational time of the pump is long, especially if the operating voltage is below the rated voltage.

The table values are calculated on the basis of the formula:

Max. cable length of a single-phase submersible pump:

$$L = \frac{U \cdot \Delta U}{I \cdot 2 \cdot 100 \cdot \left(\cos\varphi + \frac{\rho}{q} + \sin\varphi \cdot X_L\right)} \text{ m}$$

Max. cable length of a three-phase submersible pump:

$$L = \frac{U \cdot \Delta U}{I \cdot 1.73 \cdot 100 \cdot \left(\cos\varphi + \frac{\rho}{q} + \sin\varphi \cdot X_L\right)} \text{ m}$$

where

U = Rated voltage [V]

ΔU = Voltage drop [%]

I = Rated current of the motor [A]

q = Cross-section of submersible drop cable [mm^2]

X_L = Inductive resistance: 0.078 x 10^{-3} [Ω/m]

cos φ = Power factor

$\sin\varphi = \sqrt{1 - \cos^2\varphi}$

ρ = Specific resistance: 0.02 [Ω mm^2/m]

Example

Motor size: 30 kW, MMS 8000

Rated current: 64.0 A

Rated voltage: 3 x 460 V, 60 Hz

Starting method: Direct-on-line

Power factor: cos φ = 0.85

Voltage drop: 3 %

Cross-section: 16 mm^2

sin φ: 0.53

$$L = \frac{460 \cdot 3}{64.0 \cdot 1.73 \cdot 100 \cdot \left(0.85 + \frac{0.02}{16} + 0.53 \cdot 0.078 \cdot 10^{-3}\right)}$$

L = 113 m

Cable dimensions at 1 x 220 V, 60 Hz

Motor	kW	I_n [A]	1.5 mm^2	2.5 mm^2	4 mm^2	6 mm^2	10 mm^2
4"	0.25	3.3	96	159	254	379	624
	0.37	4.4	73	121	192	286	472
	0.55	6.6	48	80	127	189	311
	0.75	7.7	37	62	98	147	243
	1.1	9.0	30	50	79	118	196

Maximum cable length in meters from motor starter to pump.

Cable sizing chart

1 phase, 60 Hz

Motor rating		Copper wire size												
Volts	Hp	14	12	10	8	6	4	2	0	00	000	0000	250	300
		Maximum motor cable length (motor service to entrance) [ft/m]												
115	0.33	130 (40)	210 (64)	340 (104)	540 (165)	840 (256)	1300 (396)	1960 (597)	2910 (887)					
	0.5	100 (30)	160 (49)	250 (76)	390 (119)	620 (189)	960 (293)	1460 (445)	2160 (658)					
	0.33	550 (168)	880 (268)	1390 (424)	2190 (668)	3400 (1036)	5250 (1600)	7960 (2426)						
	0.5	400 (122)	650 (198)	1020 (311)	1610 (491)	2510 (765)	3880 (1183)	5880 (1792)						
	0.75	300 (91)	480 (146)	760 (232)	1200 (366)	1870 (570)	2890 (881)	4370 (1332)	6470 (1972)					
	1	250 (76)	400 (122)	630 (192)	990 (302)	1540 (469)	2380 (725)	3610 (1100)	5360 (1634)	6520 (1987)				
	1.5	190 (58)	310 (94)	480 (146)	770 (235)	1200 (366)	1870 (570)	2850 (869)	4280 (1305)	5240 (1597)				
	2	150 (46)	250 (76)	390 (119)	620 (189)	970 (296)	1530 (466)	2360 (719)	3620 (1103)	4480 (1366)				
	3	120 (37)	190 (58)	300 (91)	470 (143)	750 (229)	1190 (363)	1850 (564)	2890 (881)	3610 (1100)				
	5			180 (55)	280 (85)	450 (137)	710 (216)	1110 (338)	1740 (530)	2170 (661)				
	7.5				200 (61)	310 (94)	490 (149)	750 (229)	1140 (347)	1410 (430)				
	10					250 (76)	390 (119)	600 (183)	930 (283)	1160 (354)				

3 phase, 60 Hz

Motor rating		Copper wire size												
Volts	Hp	14	12	10	8	6	4	2	0	00	000	0000	250	300
		Maximum motor cable length (motor service to entrance) [ft/m]												
208	1.5	310 (94)	500 (152)	790 (241)	1260 (384)									
	2	240 (73)	390 (119)	610 (186)	970 (296)	1520 (463)								
	3	180 (55)	290 (88)	470 (143)	740 (226)	1160 (354)	1810 (552)							
	5		170 (52)	280 (85)	440 (134)	690 (210)	1080 (329)	1660 (506)						
	7.5			200 (61)	310 (94)	490 (149)	770 (235)	1180 (360)	1770 (539)					
	10				230 (70)	370 (113)	570 (174)	880 (268)	1330 (405)	1640 (500)				
	15					250 (76)	390 (119)	600 (183)	910 (277)	1110 (338)	1340 (408)			
	20						300 (91)	460 (140)	700 (213)	860 (262)	1050 (320)	1270 (387)		
	25							370 (113)	570 (174)	700 (213)	840 (256)	1030 (314)	1170 (357)	
	30							310 (94)	470 (143)	580 (177)	700 (213)	850 (259)	970 (296)	1110 (338)
230	1.5	360 (110)	580 (177)	920 (280)	1450 (442)									
	2	280 (85)	450 (137)	700 (213)	1110 (338)	1740 (530)								
	3	210 (64)	340 (104)	540 (165)	860 (262)	1340 (408)	2080 (634)							
	5		200 (61)	320 (98)	510 (155)	800 (244)	1240 (378)	1900 (579)						
	7.5			230 (70)	360 (110)	570 (174)	890 (271)	1350 (411)	2030 (619)					
	10				270 (82)	420 (128)	660 (201)	1010 (308)	1520 (463)	1870 (570)				
	15					290 (88)	450 (137)	690 (210)	1040 (317)	1280 (390)	1540 (469)			
	20						350 (107)	530 (162)	810 (247)	990 (302)	1200 (366)	1450 (442)		
	25						280 (85)	430 (131)	650 (198)	800 (244)	970 (296)	1170 (357)	1340 (408)	
	30							350 (107)	540 (165)	660 (201)	800 (244)	970 (296)	1110 (338)	1270 (387)
460	1.5	1700 (518)												
	2	1300 (396)	2070 (631)											
	3	1000 (305)	1600 (488)	2520 (768)										
	5	590 (180)	950 (290)	1500 (457)	2360 (719)									
	7.5	420 (128)	680 (207)	1070 (326)	1690 (515)	2640 (805)								
	10	310 (94)	500 (152)	790 (241)	1250 (381)	1960 (597)	3050 (930)							
	15			540 (165)	850 (259)	1340 (408)	2090 (637)	3200 (975)						
	20			410 (125)	650 (198)	1030 (314)	1610 (491)	2470 (753)	3730 (1137)					
	25				530 (162)	830 (253)	1300 (396)	1990 (607)	3010 (917)	3700 (1128)				
	30				430 (131)	680 (207)	1070 (326)	1640 (500)	2490 (759)	3060 (933)	3700 (1128)			
	40						790 (241)	1210 (369)	1830 (558)	2250 (686)	2710 (826)	3290 (1003)		
	50						640 (195)	980 (299)	1480 (451)	1810 (552)	2190 (668)	2650 (808)	3010 (917)	
	60							830 (253)	1250 (381)	1540 (469)	1850 (564)	2240 (683)	2540 (774)	2890 (881)
	75								1030 (314)	1260 (384)	1520 (463)	1850 (564)	2100 (640)	2400 (732)
	100									940 (287)	1130 (344)	1380 (421)	1560 (475)	1790 (546)
	125											1080 (329)	1220 (372)	1390 (424)
	150												1050 (320)	1190 (363)
	200												1080 (329)	1300 (396)
	250													1080 (329)

3 phase, 60 Hz														
Motor rating		Copper wire size												
Volts	Hp	14	12	10	8	6	4	2	0	00	000	0000	250	300
		Maximum motor cable length (motor service to entrance) [ft/m]												
575	1.5	2620 (799)												
	2	2030 (619)												
	3	1580 (482)	2530 (771)											
	5	920 (280)	1480 (451)	2330 (710)										
	7.5	660 (201)	1060 (323)	1680 (512)	2650 (808)									
	10	490 (149)	780 (238)	1240 (378)	1950 (594)									
	15		530 (162)	850 (259)	1340 (408)	2090 (637)								
	20			650 (198)	1030 (314)	1610 (491)	2520 (768)							
	25			520 (158)	830 (253)	1300 (396)	2030 (619)	3110 (948)						
	30				680 (207)	1070 (326)	1670 (509)	2560 (780)	3880 (1183)					
	40					790 (241)	1240 (378)	1900 (579)	2860 (872)	3510 (1070)				
	50						1000 (305)	1540 (469)	2310 (704)	2840 (866)	3420 (1042)			
	60						850 (259)	1300 (396)	1960 (597)	2400 (732)	2890 (881)	3500 (1067)		
	75							1060 (323)	1600 (488)	1970 (600)	2380 (725)	2890 (881)	3290 (1003)	

CAUTION: Use of wire size smaller than listed will void warranty.

Notes:

1. If aluminum conductor is used, multiply lengths by 0.5 Maximum allowable length of aluminum is considerably shorter than copper wire of same size.
2. The portion of the total cable which is between the service entrance and a 3ø motor starter should not exceed 25% of the total maximum length to assure reliable starter operation. Single-phase control boxes may be connected at any point of the total cable length.
3. Cables #14 to #0000 are AWG sizes, and 250 to 300 are MCM sizes.

10. Friction loss tables

Friction loss table - SCH 40 steel pipe										
		.5"	.75"	1"	1.25"	1.5"	2"	2.5"	3"	4"
U.S. gpm	U.S. gph	ID 0.622"	ID 0.824"	ID 1.049"	ID 1.380"	ID 1.610"	ID 2.067"	ID 2.469"	ID 3.068"	ID 4.026"
		Friction loss in feet of head per 100 feet of pipe								
2	120	4.8								
3	180	10.0	2.5							
4	240	17.1	4.2							
5	300	25.8	6.3	1.9						
6	360	36.5	8.9	2.7						
7	420	48.7	11.8	3.6						
8	480	62.7	15.0	4.5						
9	540	78.3	18.8	5.7						
10	600	95.9	23.0	6.9						
12	720		32.6	9.6	2.5	1.2				
14	840		43.5	12.8	3.3	1.5				
16	960		56.3	16.5	4.2	2.0				
20	1,200		86.1	25.1	6.3	2.9				
25	1,500			38.7	9.6	4.5	1.3			
30	1,800			54.6	13.6	6.3	1.8			
35	2,100			73.3	18.2	8.4	2.4			
40	2,400			95.0	23.5	10.8	3.1	1.3		
45	2,700				29.4	13.5	3.9	1.6		
50	3,000				36.0	16.4	4.7	1.9		
60	3,600				51.0	23.2	6.6	2.7		
70	4,200				68.8	31.3	8.9	3.6	1.2	
80	4,800				89.2	40.5	11.4	4.6	1.6	
90	5,400					51.0	14.2	5.8	2.0	
100	6,000					62.2	17.4	7.1	2.4	
120	7,200						24.7	10.1	3.4	
140	8,400						33.2	13.5	4.5	1.2
160	9,600						43.0	17.5	5.8	1.5
200	12,000						66.3	27.0	8.9	2.3
260	15,600							45.0	14.8	3.7
300	18,000							59.6	19.5	4.9

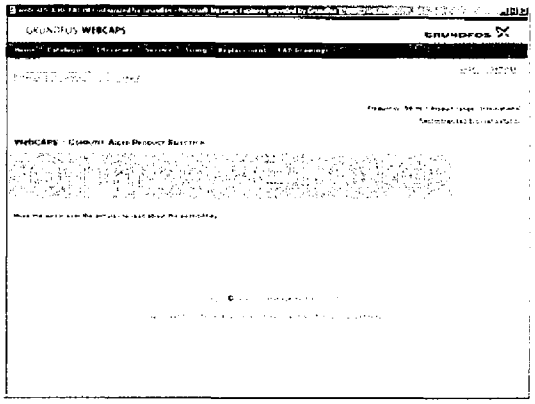
Friction loss table - SCH 40 PVC pipe										
		.5"	.75"	1"	1.25"	1.5"	2"	2.5"	3"	4"
U.S. gpm	U.S. gph	ID 0.622"	ID 0.824"	ID 1.049"	ID 1.380"	ID 1.610"	ID 2.067"	ID 2.469"	ID 3.068"	ID 4.026"
		Friction loss in feet of head per 100 feet of pipe								
2	120	4.1								
3	180	8.7	2.2							
4	240	14.8	3.7							
5	300	22.2	5.7	1.8						
6	360	31.2	8.0	2.5						
7	420	41.5	10.6	3.3						
8	480	53.0	13.5	4.2						
9	540	66.0	16.8	5.2						
10	600	80.5	20.4	6.3	1.7					
12	720		28.6	8.9	2.3	1.1				
14	840		38.0	11.8	3.1	1.4				
16	960		48.6	15.1	4.0	1.9				
20	1,200		60.5	22.8	6.0	2.8				
25	1,500			38.7	9.1	4.3	1.3			
30	1,800				12.7	6.0	1.8			
35	2,100				16.9	8.0	2.4			
40	2,400				21.6	10.2	3.0	1.1		
45	2,700				28.0	12.5	3.8	1.4		
50	3,000					15.4	4.6	1.7		
60	3,600					21.6	6.4	2.3		
70	4,200					28.7	8.5	3.0	1.2	
80	4,800					36.8	10.9	3.8	1.4	
90	5,400					45.7	13.6	4.8	1.8	
100	6,000					56.6	16.5	5.7	2.2	
120	7,200						23.1	8.0	3.0	
140	8,400						30.6	10.5	4.0	1.1
160	9,600						39.3	13.4	5.0	1.4
200	12,000						66.3	20.1	7.6	2.1
260	15,600							32.4	12.2	3.4
300	18,000							42.1	15.8	4.4

Type of fitting and application	Pipe and fitting	Nominal size of fitting and pipe						
		1/2"	3/4"	1"	1.25"	1.5"	2"	2.5"
		Friction loss in equivalent length of straight pipe in feet						
Insert coupling	Plastic	3	3	3	3	3	3	3
Threaded adapter (plastic to thread)	Plastic	3	3	3	3	3	3	3
90° standard elbow	Steel	2	2	3	4	4	5	6
	Plastic	2	2	3	4	4	5	6
Standard tee (flow through run)	Steel	1	2	2	3	3	4	4
	Plastic	1	2	2	3	3	4	4
Standard tee (flow through side)	Steel	4	5	6	7	8	11	13
	Plastic	4	5	6	7	8	11	13
Gate valve[1]	Steel	1	1	1	1	2	2	2
Swing check valve[1]	Steel	5	7	9	12	13	17	21

Notes:
Based on Schedule 40 steel and plastic fittings
[1]Friction loss figures are for screwed valves and are based on equivalent lengths of steel pipe.

11. Further product documentation

WebCAPS

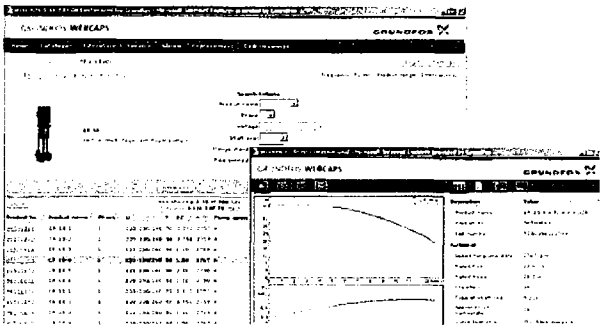


WebCAPS is a **Web**-based Computer Aided Product Selection program available on www.grundfos.com.

WebCAPS contains detailed information on more than 185,000 Grundfos products in more than 20 languages.

In WebCAPS, all information is divided into 6 sections:

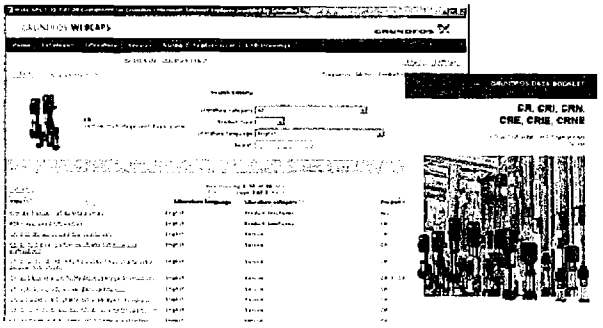
- Catalog
- Literature
- Service
- Sizing
- Replacement
- CAD drawings.



Catalog

This section is based on fields of application and pump types, and contains

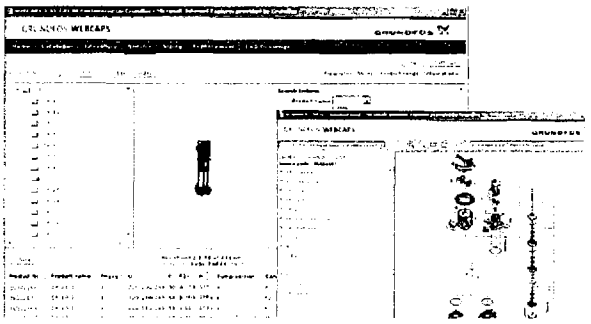
- technical data
- curves (QH, Eta, P1, P2, etc) which can be adapted to the density and viscosity of the pumped liquid and show the number of pumps in operation
- product photos
- dimensional drawings
- wiring diagrams
- quotation texts, etc.



Literature

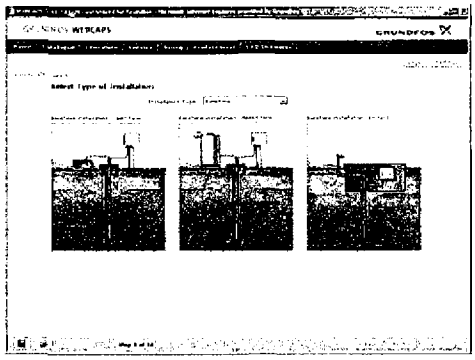
In this section you can access all the latest documents of a given pump, such as

- product guides
- installation and operating instructions
- service documentation, such as Service kit catalog and Service kit instructions
- quick guides
- product brochures, etc.



Service

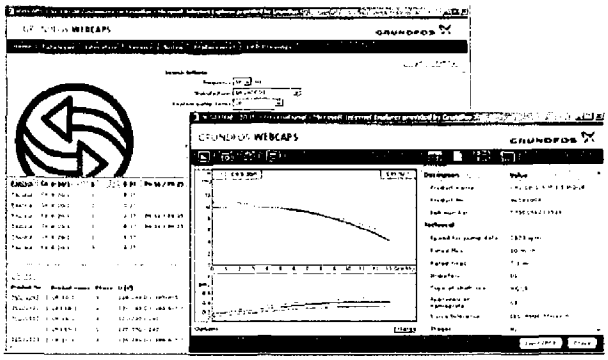
This section contains an easy-to-use interactive service catalog. Here you can find and identify service parts of both existing and discontinued Grundfos pumps.
Furthermore, this section contains service videos showing you how to replace service parts.



Sizing

This section is based on different fields of application and installation examples, and gives easy step-by-step instructions in how to

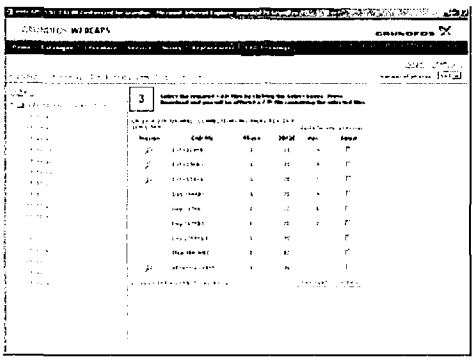
- select the most suitable and efficient pump for your installation
- carry out advanced calculations based on energy consumption, payback periods, load profiles, life cycle costs, etc.
- analyse your selected pump via the built-in life cycle cost tool
- determine the flow velocity in wastewater applications, etc.



Replacement

In this section you find a guide to selecting and comparing replacement data of an installed pump in order to replace the pump with a more efficient Grundfos pump.
The section contains replacement data of a wide range of pumps produced by other manufacturers than Grundfos.

Based on an easy step-by-step guide, you can compare Grundfos pumps with the one you have installed on your site. When you have specified the installed pump, the guide will suggest a number of Grundfos pumps which can improve both comfort and efficiency.



CAD drawings

In this section it is possible to download 2-dimensional (2D) and 3-dimensional (3D) CAD drawings of most Grundfos pumps.

These formats are available in WebCAPS:

2-dimensional drawings:
- .dxf, wireframe drawings
- .dwg, wireframe drawings.

3-dimensional drawings:
- .dwg, wireframe drawings (without surfaces)
- .stp, solid drawings (with surfaces)
- .eprt, E-drawings.

WinCAPS

Fig. 28 WinCAPS CD-ROM

WinCAPS is a Windows-based Computer Aided Product Selection program containing detailed information on more than 185,000 Grundfos products in more than 20 languages.

The program contains the same features and functions as WebCAPS, but is an ideal solution if no Internet connection is available.

WinCAPS is available on CD-ROM and updated once a year.

BE > THINK > INNOVATE >

Being responsible is our foundation
Thinking ahead makes it possible
Innovation is the essence

L-SP-PG-001 0212

Repl. L-SP-PG-001 Rev. 0206 US

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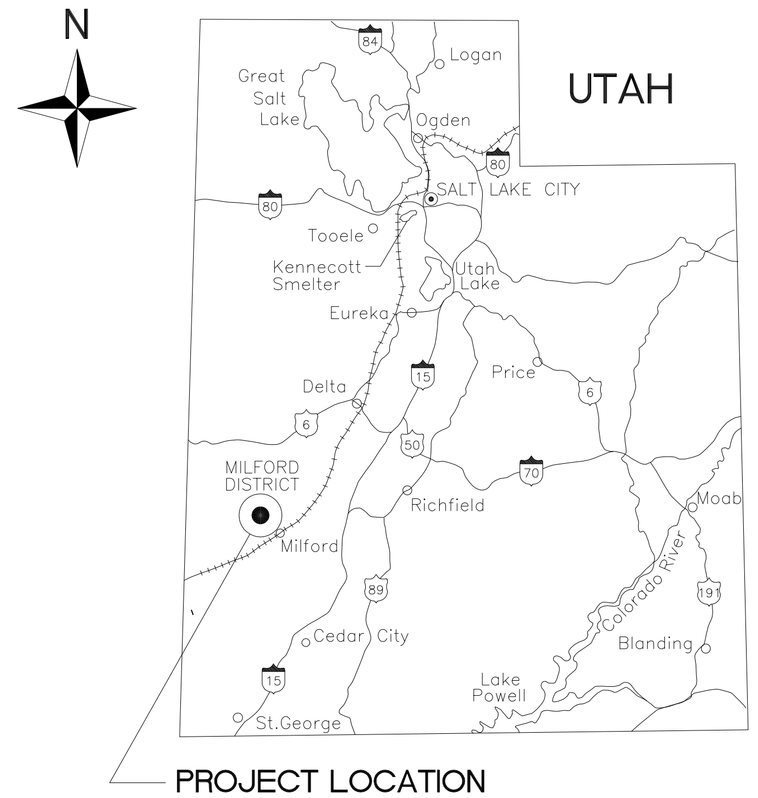
GRUNDFOS

CS MINING LLC

TAILINGS LEACH/CCD PROJECT - PHASE 1
SOLVENT EXTRACTION, ELECTROWINNING

MILFORD, UTAH



INDEX OF DRAWINGS

DRAWING NUMBER	DESCRIPTION
GENERAL ARRANGEMENT	
00-GA-00	INDEX OF DRAWINGS AND SPECIFICATIONS
00-GA-01	PROCESS PLANT SITE LAYOUT
SOLVENT EXTRACTION	
30-FS-01	FLOWSHEET
30-GA-01	UNIT LAYOUT
30-GA-02	UNIT CONCRETE PLAN
ELECTROWINNING	
40-FS-01	FLOWSHEET
40-GA-01	UNIT LAYOUT
40-CN-02	POLYMER CONCRETE - CELL DETAILS
40-M-02	CATHODE AND ANODE DETAILS
TANK FARM	
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DRAWING NUMBER	DESCRIPTION
LEACH CIRCUIT TANKS/CCD	
60-FS-01	FLOWSHEET
60-GA-01	LEACH CIRCUIT TANKS LAYOUT
61-GA-01 (SHT-1)	CCD THICKENERS CIRCUIT LAYOUT
61-GA-01 (SHT-2)	CCD THICKENERS CIRCUIT SECTION
62-GA-01	ACID STORAGE UNIT LAYOUT
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PONDS	
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80-GA-02	SECTIONS AND DETAILS
80-GA-03	SECTIONS AND DETAILS
80-GA-04	SECTIONS AND DETAILS
80-GA-05	SECTIONS AND DETAILS

ABBREVIATIONS

ANCHOR BOLT	AB	GRADE	GR
AT	AT	GRATING	GRTG
BLIND FLANGE	BF	HIGH POINT	H.P.
BEAM	BM	HIGH STRENGTH BOLT	H.S.B.
BOTTOM	BOT	HORIZONTAL	HORIZ.
BOTTOM OF BASE PLATE	B.O.BP	INCH	IN
BOTTOM OF PIPE	B.O.P.	INSIDE DIAMETER	I.D.
BOLT CIRCLE	BC	INSIDE RADIUS	I.R.
BUILDING	BLDG	JOINT	JT
CENTERLINE	CL	LONG	LG
CLEAR	CLR	MAXIMUM	MAX.
CHECKERED PLATE CONVEYOR	CHKD PL CONV	MINIMUM	MIN.
COLUMN	COL	MODIFIED	MOD.
CONCENTRIC REDUCER	CONC. RED.	NEAR SIDE	NS
CONCRETE	CONC	NOT IN CONTRACT	N.I.C.
CONTROL PANEL	CP	NOT TO SCALE	N.T.S.
CONTINUOUS	CONT.	ON CENTER	O.C.
CUBIC FOOT	CU FT	OUTSIDE DIAMETER	O.D.
DIAMETER	DIA	PLATE	PL
DIMENSION	DIM	POUND	LB
DOWN	DN	RADIUS	RAD
DRAWING	DWG	REFERENCE	REF
EACH	EA	RELOCATED	RELOC.
EACH WAY	EW	SQUARE FOOT	SQ FT
ELBOW	ELL	STANDARD	STD
ELEVATION	ELEV	STEEL	STL
EQUAL	EQ	STIFFENER	STFNR
EQUIPMENT	EQUIP	TOP AND BOTTOM	T AND B
EXISTING	E.	TOP OF CONCRETE	T.O.C.
EXPANSION	EXP	TOP OF GRATING	T.O.G.
EXPANSION JOINT	EJ	TOP OF STEEL	T.O.S.
FINISH GRADE	FIN. GR.	TYPICAL	TYP.
FOOT	FT	UNLESS NOTED OTHERWISE	U.N.O.
FOOTING	FTG	VERTICAL	VERT.
FOUNDATION	FND	WEATHERPROOF	WP
GAGE	GA	WITH	W/
GALLON	GAL	WORK POINT	W.P.

PRELIMINARY
NOT FOR CONSTRUCTION
11-06-2013

TOLERANCE UNLESS OTHERWISE SPECIFIED: FRACTIONS ±; 0.00 ±; 0.000 ±

REVISIONS (DESTROY ALL PRINTS OF AN EARLIER DATE THAN LATEST REVISION)

REV	DESCRIPTION	BY	DATE
P1	FIRST REVIEW	HM	12/06/13

REV	DESCRIPTION	BY	DATE

CS Mining LLC

PROJECT NO 2012-01

WESTERN STATES ENGINEERING
5210 E. Williams Circle, Suite 700
TUCSON, AZ 85711
PHONE: 520-889-2040 FAX: 520-889-2733

APPROVED FOR CONSTRUCTION

	BY	DATE		BY	DATE
SAFETY			PROCESS ENGR.		
ENVIRONMENTAL			PROJECT ENGR.		
MAINTENANCE			ENGR. MNGR.		
PRODUCTION			PLANT MNGR.		
QLTY. CONTROL					

DESIGN		DATE
DRAWN BY	AM	11/06/13
PROJ. ENGR.	HM	
ENGR. MNGR.		

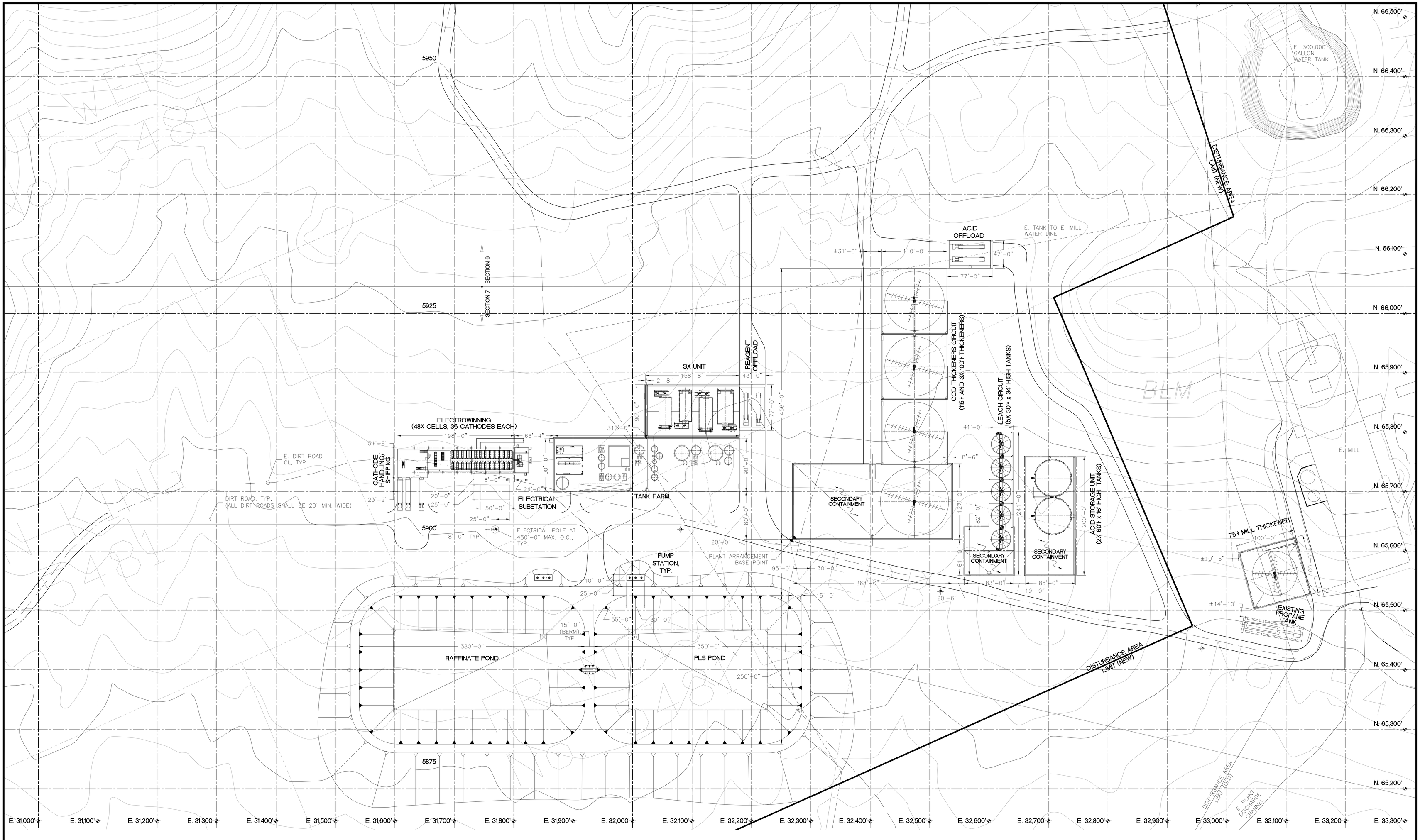
COPPER LEACH/CCD PROJECT - PHASE 1
SOLVENT EXTRACTION, ELECTROWINNING
GENERAL ARRANGEMENT
INDEX OF DRAWINGS AND SPECIFICATIONS

SCALE: AS NOTED

DRAWING NO. 00-GA-00

SHEET 1 OF 1

REVISION P1



PROCESS PLANT SITE PLAN

SCALE: 1" = 60'-0"

2,500 TPD ORE DESIGN RATE – PHASE 1a OPTION.
3,500 TPD ORE DESIGN RATE – PHASE 1b OPTION.

A — N PROJECT NORTH

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11-06-2013

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REVISIONS (DESTROY ALL PRINTS OF AN EARLIER DATE THAN LATEST REVISION)

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P1	FIRST REVIEW	HM	11/06/13

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TUCSON, AZ 85711
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ENVIRONMENTAL			PROJECT ENGR.		
MAINTENANCE			ENGR. MNGR.		
PRODUCTION			PLANT MNGR.		
QLTY. CONTROL					

DESIGN		DATE
DRAWN BY	AM	11/06/13
PROJ. ENGR.	HM	
ENGR. MNGR.		

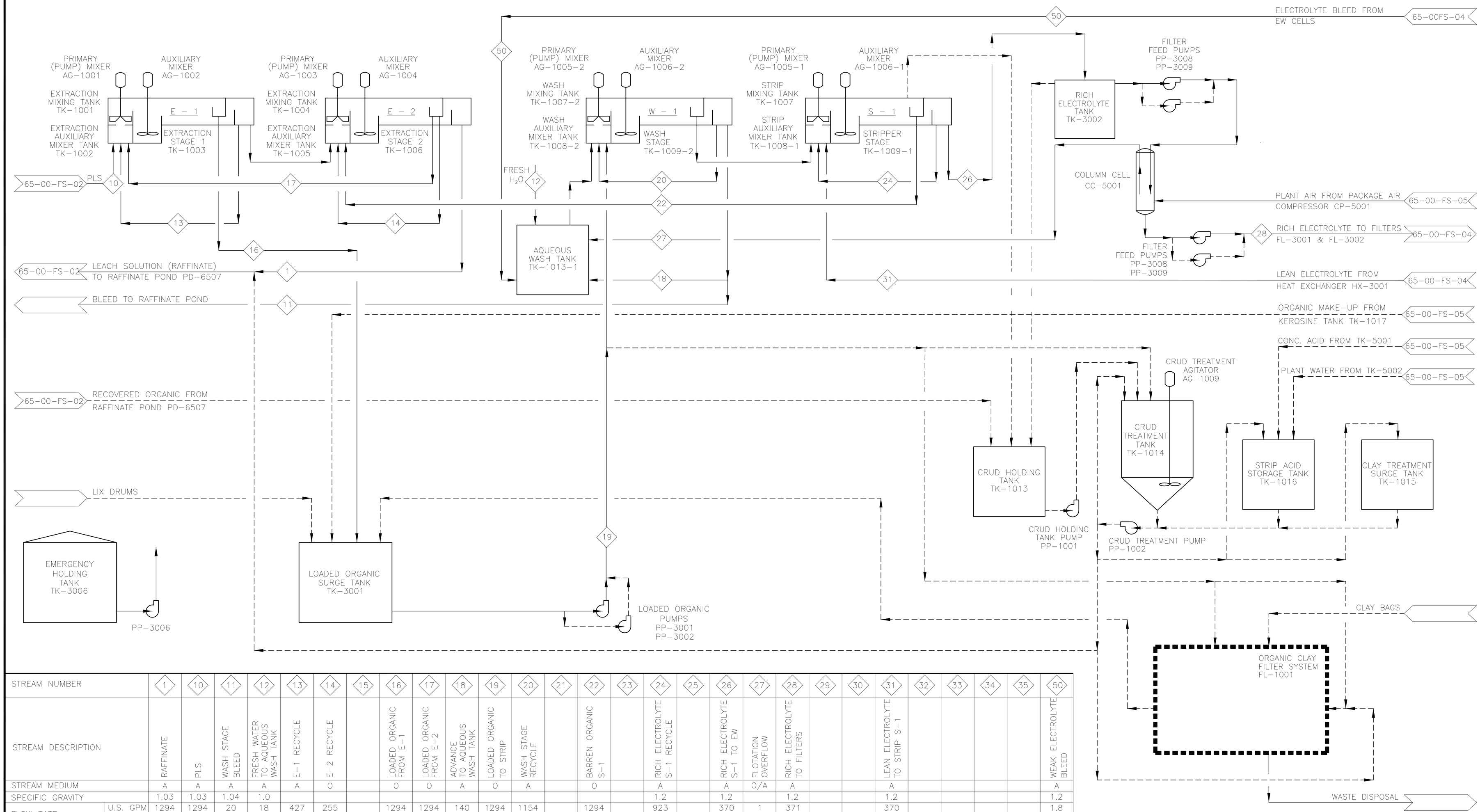
COPPER LEACH/CCD PROJECT - PHASE 1
SOLVENT EXTRACTION, ELECTROWINNING
GENERAL ARRANGEMENT
PROCESS PLANT SITE LAYOUT

SCALE: AS NOTED

DRAWING NO. 00-GA-01

SHEET 1 OF 1

REVISION P1



STREAM NUMBER		1	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	50
STREAM DESCRIPTION		RAFFINATE	PLS	WASH STAGE BLEED	FRESH WATER TO AQUEOUS WASH TANK	E-1 RECYCLE	E-2 RECYCLE		LOADED ORGANIC FROM E-1	LOADED ORGANIC FROM E-2	ADVANCE TO AQUEOUS WASH TANK	LOADED ORGANIC TO STRIP	WASH STAGE RECYCLE		BARREN ORGANIC S-1		RICH ELECTROLYTE S-1 RECYCLE		RICH ELECTROLYTE S-1 TO EW	FLOTATION OVERFLOW	RICH ELECTROLYTE TO FILTERS			LEAN ELECTROLYTE TO STRIP S-1					WEAK ELECTROLYTE BLEED
STREAM MEDIUM		A	A	A	A	A	O		O	O	A	O	A		O		A		A	O/A	A			A					A
SPECIFIC GRAVITY		1.03	1.03	1.04	1.0												1.2		1.2		1.2			1.2					1.2
FLOW RATE	U.S. GPM	1294	1294	20	18	427	255		1294	1294	140	1294	1154		1294		923		370	1	371			370					1.8
COPPER CONTENT	LBS/MIN	0.55	31.3	0.15					52.1	26.4		52.1			23.1				131	0.4	131			102					
	GPL	0.05	2.8	0.9					4.74	2.40		4.74			2.10		45		45	45	45			35					35
ACID CONTENT	LBS/MIN	38.5	5.4	2.5																									
	GPL	3.5	0.49	15															180		180			189					189
DESIGN TEMPERATURE	°F																				60			60					

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CS Mining LLC

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REV	DESCRIPTION	BY	DATE

PROJECT NO 2012-01

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ENVIRONMENTAL			PROJECT ENGR.		
MAINTENANCE			ENGR. MNGR.		
PRODUCTION			PLANT MNGR.		
QLTY. CONTROL					

DESIGN	DATE
DRAWN BY AM	11/06/13
PROJ. ENGR. HM	
ENGR. MNGR.	

COPPER LEACH/CCD PROJECT - PHASE 1
SOLVENT EXTRACTION, ELECTROWINNING

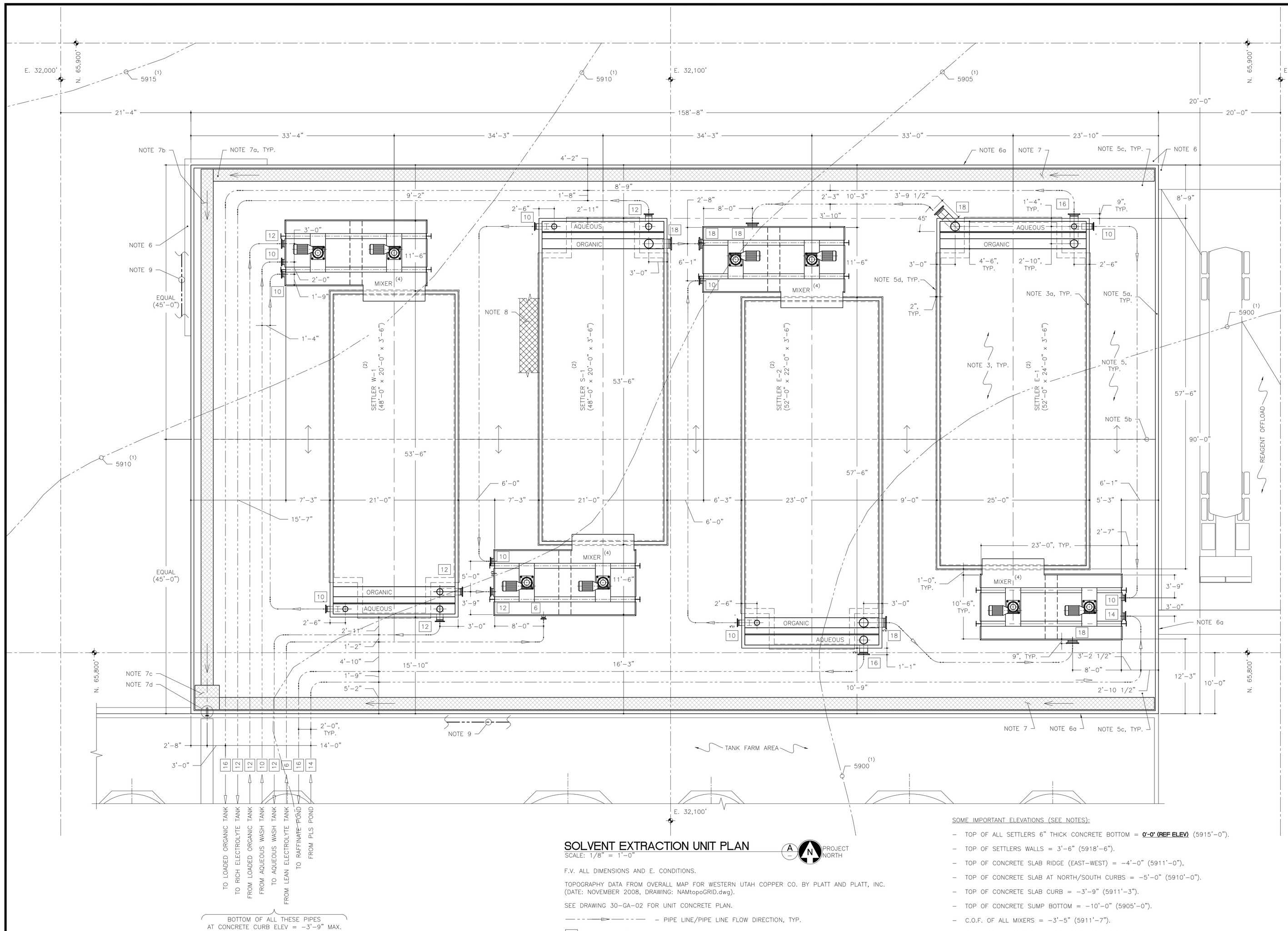
SOLVENT EXTRACTION FLOWSHEET

SCALE: AS NOTED

DRAWING NO. 30-FS-01

SHEET 1 OF 1

REVISION P1



SOLVENT EXTRACTION UNIT PLAN

SCALE: 1/8" = 1'-0"

PROJECT NORTH

F.V. ALL DIMENSIONS AND E. CONDITIONS.

TOPOGRAPHY DATA FROM OVERALL MAP FOR WESTERN UTAH COPPER CO. BY PLATT AND PLATT, INC. (DATE: NOVEMBER 2008, DRAWING: NAMtopoGRID.dwg).

SEE DRAWING 30-GA-02 FOR UNIT CONCRETE PLAN.

— PIPE LINE/PIPE LINE FLOW DIRECTION, TYP.

10 — SETTLERS/MIXERS FLANGE AND PIPE DIAMETER, INCHES. C.O.F. OF ALL MIXERS = -3'-5". SEE SETTLERS C.O.F. ELEV SCHEDULE FOR SETTLERS C.O.F. ELEV.

NOTES:

(1) GROUND CONTOUR ELEVATION, FEET.

(2) ALL SETTLERS ARE CONCRETE CONSTRUCTION W/SS SKIN/WEIRS. ALL SETTLER SHALL HAVE ROOF COVER. COVERS AREN'T PART OF THIS REVISION.

(3) TOP OF ALL SETTLERS 6" THICK CONCRETE BOTTOM = **0'-0" (REF ELEV)** = ±5915'.

(3a) ALL SETTLERS WALLS T.O.C. = 3'-6".

(4) SEE MIXERS SCHEDULE FOR MIXER INFORMATION. SEE E. DWG's M103, M104 AND M105 (YERINGTON PROJECT) FOR E. MIXERS INFORMATION. TOP OF ALL MIXERS BOXES ELEV = 3'-7". BOTTOM OF ALL MIXERS BOXES ELEV = -4'-5".

(5) 6" THICK (U.N.O.) CONCRETE SLAB. — SLAB SLOPE.

(5a) 6" WIDE CURB. T.O.C. ELEV = -3'-9".

(5b) T.O.C. HIGH ELEV OF SLAB (EAST-WEST RIDGE) = -4'-0".

(5c) T.O.C. LOW ELEV OF SLAB (EAST-WEST) = -5'-0".

(5d) 10" WIDE CONCRETE WALL (SETTLER SUPPORT). T.O.C. ELEV = -6".

(6) 1'-0" WIDE RETAINING WALL (WHERE NECESSARY).

(6a) RESTRAINING WALL BELOW (WHERE NECESSARY).

(7) 2'-0" WIDE EAST-WEST CONCRETE GUTTER (NORTH SIDE AND SOUTH SIDE).

(7a) T.O.C. LOW ELEV OF EAST-WEST GUTTER = -7'-0".

— EAST-WEST AND NORTH-SOUTH (NOTE 7b) GUTTERS SLOPE.

(7b) 2'-0" WIDE NORTH-SOUTH GUTTER (T.O.C. LOW ELEV OF GUTTER = -9'-0" - SOUTH END).

(7c) 4'-0" x 4'-0" SUMP. SUMP BOTTOM T.O.S. ELEV = -10'-0".

(7d) 3"ø SCHEDULE 80 STAINLESS STEEL PIPE WITH FLANGE AND BLIND FLANGE, PLACED THROUGH SUMP CONCRETE WALL THIS PLACE. C.O.P. ELEV = ±-9'-0".

(8) WALKWAY (STEEL SUPPORT - T.O.S. ELEV = -5 3/4"). WALKWAY DESIGN (STEEL SUPPORT, GRATING, HANDRAIL, LADDER) ISN'T PART OF THIS REVISION.

(9) HANDRAIL, WHERE NECESSARY.

SETTLERS C.O.F. ELEV SCHEDULE:

SETTLER \ FLANGE	10"ø	12"ø	16"ø	18"ø
C.O.F OF E-1	-2'-0"		-3'-3"	-3'-5"
C.O.F OF E-2	-2'-0"		-2'-9"	-3'-5"
C.O.F OF S-1	-2'-0"	-2'-3"		-3'-5"
C.O.F OF W-1	-2'-0"	-2'-3" (*)		-3'-5"

(*) 12"ø C.O.F. (CONNECTION W/ MIXER) = -3'-5".

MIXERS SCHEDULE:

SETTLER	EXISTING MIXER	MODIFICATION	NEW MIXER
E-1 EAST	M-105	ALL FLANGES SHALL BE AS SHOWN ON PLAN	
E-2 EAST	M-105		
S-1 EAST	M-103 OR M-104		
W-1 EAST			SIM. TO M-105

SOME IMPORTANT ELEVATIONS (SEE NOTES):

- TOP OF ALL SETTLERS 6" THICK CONCRETE BOTTOM = **0'-0" (REF ELEV)** (5915'-0").
- TOP OF SETTLERS WALLS = 3'-6" (5918'-6").
- TOP OF CONCRETE SLAB RIDGE (EAST-WEST) = -4'-0" (5911'-0").
- TOP OF CONCRETE SLAB AT NORTH/SOUTH CURBS = -5'-0" (5910'-0").
- TOP OF CONCRETE SLAB CURB = -3'-9" (5911'-3").
- TOP OF CONCRETE SUMP BOTTOM = -10'-0" (5905'-0").
- C.O.F. OF ALL MIXERS = -3'-5" (5911'-7").
- C.O.F. OF ALL SETTLERS - SEE SETTLERS C.O.F. ELEV SCHEDULE.
- BOTTOM OF ALL PIPES AT SOUTH CONCRETE CURB = -3'-9" MAX. (5911'-3" MAX).

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CS Mining LLC

PROJECT NO 2012-01

WESTERN STATES ENGINEERING
5210 E. Williams Circle, Suite 700
TUCSON, AZ 85711
PHONE: 520-889-2040 FAX: 520-889-2733

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MAINTENANCE			ENGR. MNGR.		
PRODUCTION			PLANT MNGR.		
QLTY. CONTROL					

DESIGN		DATE
DRAWN BY	AM	11/06/13
PROJ. ENGR.	HM	
ENGR. MNGR.		

COPPER LEACH/CCD PROJECT - PHASE 1
SOLVENT EXTRACTION, ELECTROWINNING

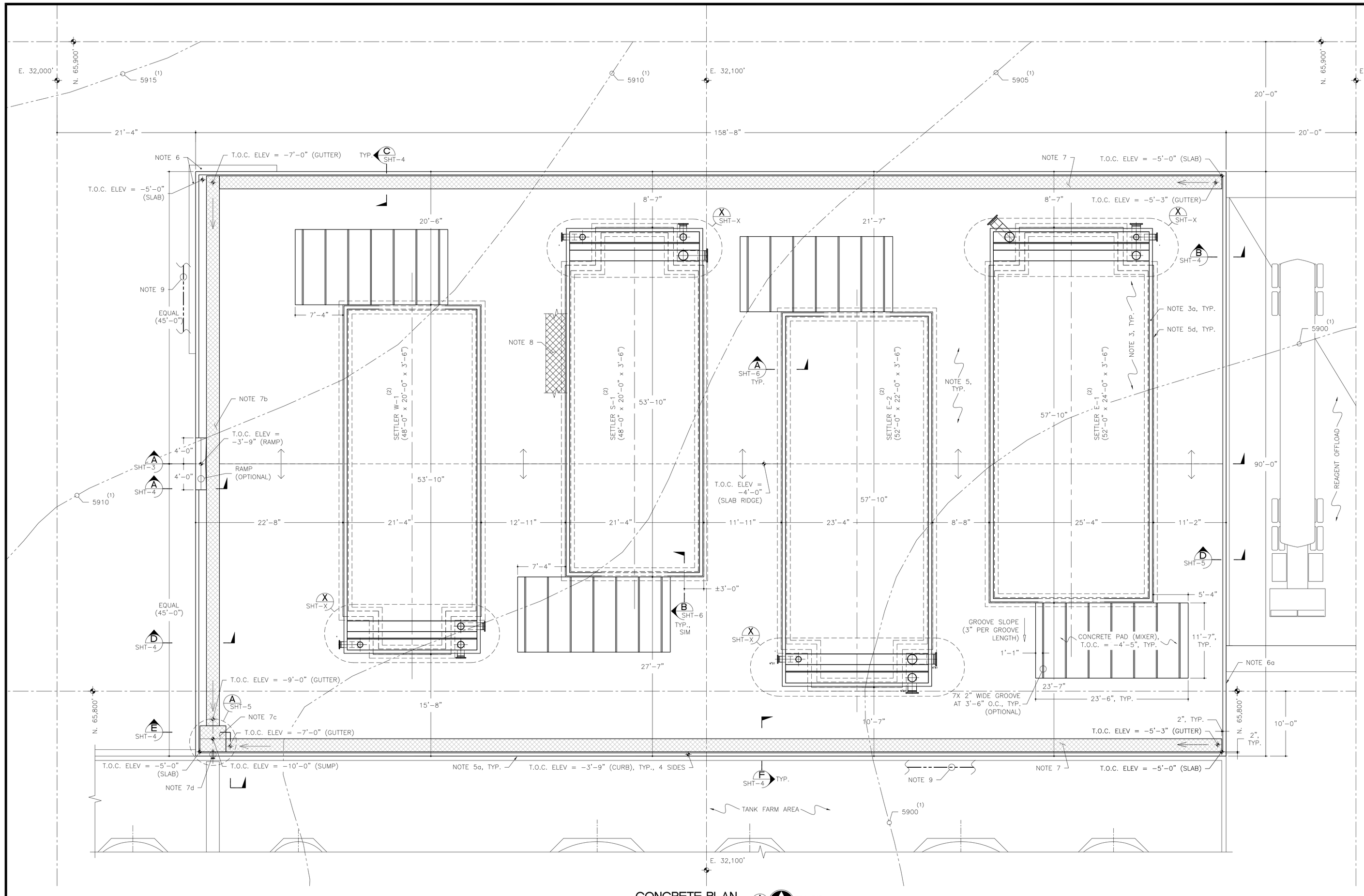
SOLVENT EXTRACTION
UNIT LAYOUT

SCALE: AS NOTED

DRAWING NO. 30-GA-01

SHEET 1 OF X

REVISION P1



CONCRETE PLAN

SCALE: 1/8" = 1'-0"

A — PROJECT NORTH

NOTES:

(1) GROUND CONTOUR ELEVATION, FEET.

(2) ALL SETTLERS ARE CONCRETE CONSTRUCTION W/SS SKIN/WEIRS.

(3) TOP OF ALL SETTLERS 6" THICK CONCRETE BOTTOM = **0'-0" (REF ELEV)** = ±5915'.

(3a) ALL SETTLERS WALLS T.O.C. = 3'-6".

(4) NOT USED.

(5) 6" THICK (U.N.O.) CONCRETE SLAB W/ #4 AT 12" O.C., CENTERED, EW.
PROVIDE CONTROL JOINTS AT ±25'-0" O.C., EW
(JOINT SHALL BE 3/16" MAX. WIDE AND 1/4" DEEP.
THIS SIZE TROWEL CUT SHALL BE MADE SOON ENOUGH TO PREVENT CRACKING,
BUT NOT SO SOON TO CAUSE SPALLING OF THE CONCRETE WHILE SAWING).

↓ – SLAB SLOPE.

(5a) 6" WIDE CURB.

(5b) THROUGH (5c) – NOT USED.

(5d) 10" WIDE CONCRETE WALL (SETTLER SUPPORT).
T.O.C. ELEV = -6".

(6) 1'-0" WIDE RETAINING WALL (WHERE NECESSARY).

(6a) RESTRAINING WALL BELOW (WHERE NECESSARY).

(7) 2'-0" WIDE EAST-WEST CONCRETE GUTTER (NORTH SIDE AND SOUTH SIDE).
⟶ – EAST-WEST AND NORTH-SOUTH (NOTE 7b) GUTTERS SLOPE.

(7a) NOT USED.

(7b) 2'-0" WIDE NORTH-SOUTH GUTTER

(7c) 4'-0" x 4'-0" SUMP.

(7d) 3"ø SCHEDULE 80 STAINLESS STEEL PIPE WITH FLANGE AND BLIND FLANGE, PLACED THROUGH SUMP CONCRETE WALL THIS PLACE. C.O.P. ELEV = ±-9'-0".

(8) WALKWAY (STEEL SUPPORT – T.O.S. ELEV = -5 3/4").
WALKWAY DESIGN (STEEL SUPPORT, GRATING, HANDRAIL, LADDER) ISN'T PART OF THIS REVISION.
(9) GROOVES AT TOP OF MIXER CONCRETE PADS ARE OPTIONAL (AT OWNER DISCRETION).

(9) HANDRAIL, WHERE NECESSARY.

SOME IMPORTANT ELEVATIONS (SEE NOTES):

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- TOP OF CONCRETE SLAB CURB = -3'-9" (5911'-3").
- TOP OF CONCRETE SUMP BOTTOM = -10'-0" (5905'-0").
- TOP OF CONCRETE PADS (MIXERS) = -4'-5" (5910'-7").

F.V. ALL DIMENSIONS AND E. CONDITIONS.

TOPOGRAPHY DATA FROM OVERALL MAP FOR WESTERN UTAH COPPER CO. BY PLATT AND PLATT, INC. (DATE: NOVEMBER 2008, DRAWING: NAMtopoGRID.dwg).

PIPING SUPPORTS ARE NOT SHOWN IN THIS REVISION. SEE DWG 30-GA-01 FOR PIPING INFORMATION.

CHAMFER EXPOSED CONCRETE CORNERS: 3/4" x 45°.

REGRADE AREA FOR CONCRETE SLAB AS NECESSARY. SOIL PREPARATION SHALL BE AS FOLLOW:
a) REMOVE EXISTING TOP SOIL. THE DEPTH MAY BE ADJUSTED BASED UPON ACTUAL FIELD CONDITION AFTER EXCAVATION IS COMPLETED.
b) PROVIDE A WELL ENGINEERED FILL MATERIAL (I.E. TYPE II SOIL).
c) PROVIDE A MINIMUM OF 95% COMPACTION (ASTM D1557).
d) MAXIMUM LIFT IS NOT TO EXCEED 10" OF LOOSE DEPTH.

EARTH ADJACENT TO NEW CONCRETE TO BE WELL COMPACTED TO PREVENT FUTURE DIFFERENTIAL SETTLEMENT.
PROVIDE 3" MIN. SLOPE FROM ADJACENT CONCRETE. PROVIDE WATER DRAINAGE AROUND AS NECESSARY.
DRAINAGE SHALL BE TYPE D1 (SEE TYP. SECTION D/SHT-6) AND 5'-0" MIN. FROM CONCRETE SLAB/WALL.

PROVIDE CONCRETE AND REBAR PROTECTIVE COATING.

PROVIDE WATER STOPS AS NECESSARY.

MINIMUM CONCRETE COVER FOR REINFORCING BARS: 1 1/2", U.N.O.

SEE DTL C/SHT-5 FOR TYP. FOOTING AND WALL REINFORCING AT INTERSECTION.

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COPPER LEACH/CCD PROJECT - PHASE 1
SOLVENT EXTRACTION, ELECTROWINNING

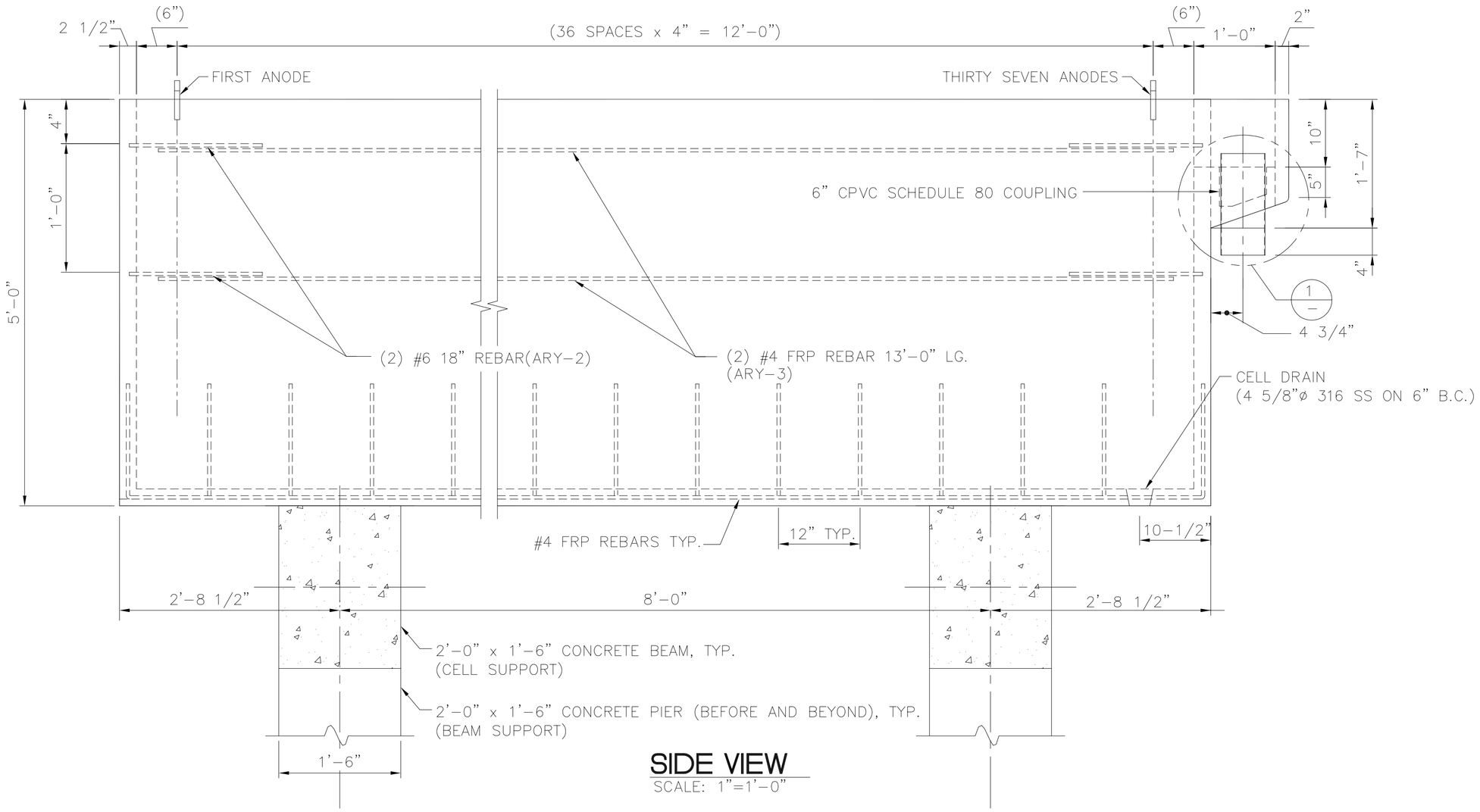
SOLVENT EXTRACTION
UNIT CONCRETE PLAN

SCALE: AS NOTED

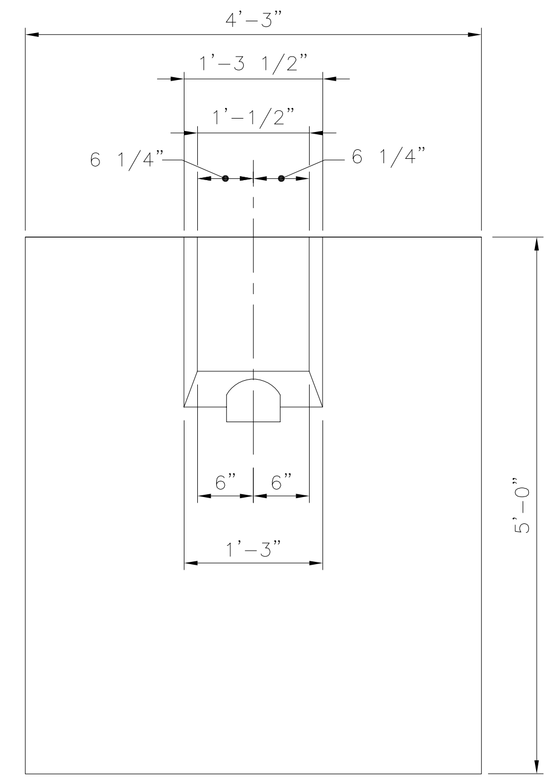
DRAWING NO. 30-GA-02

SHEET 1 OF X

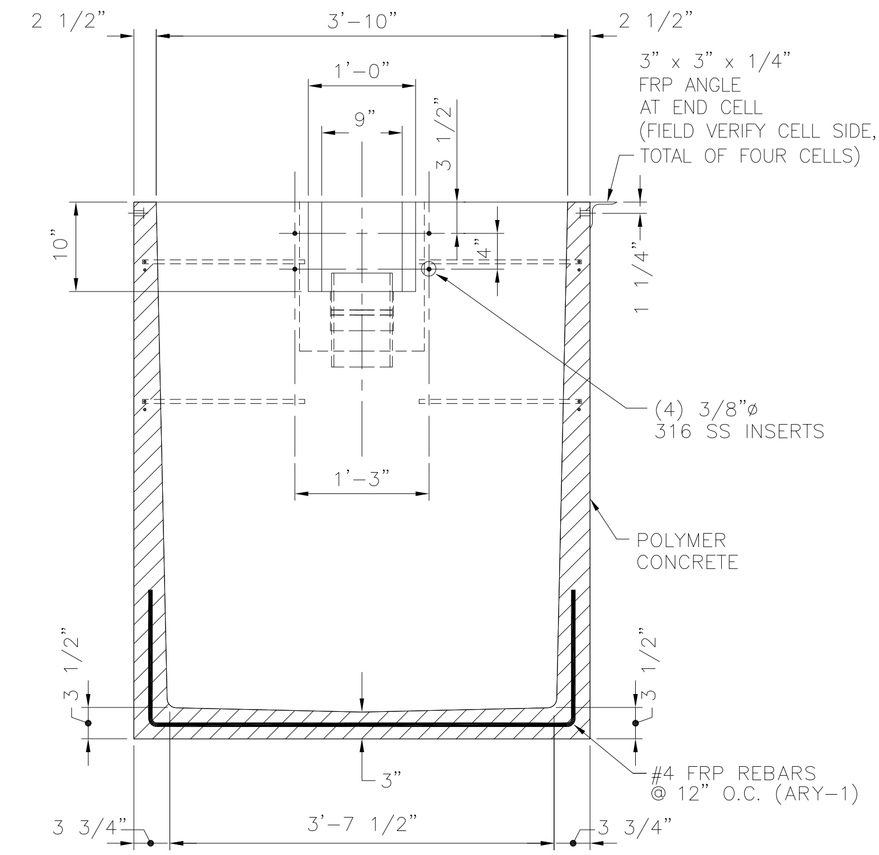
REVISION P1



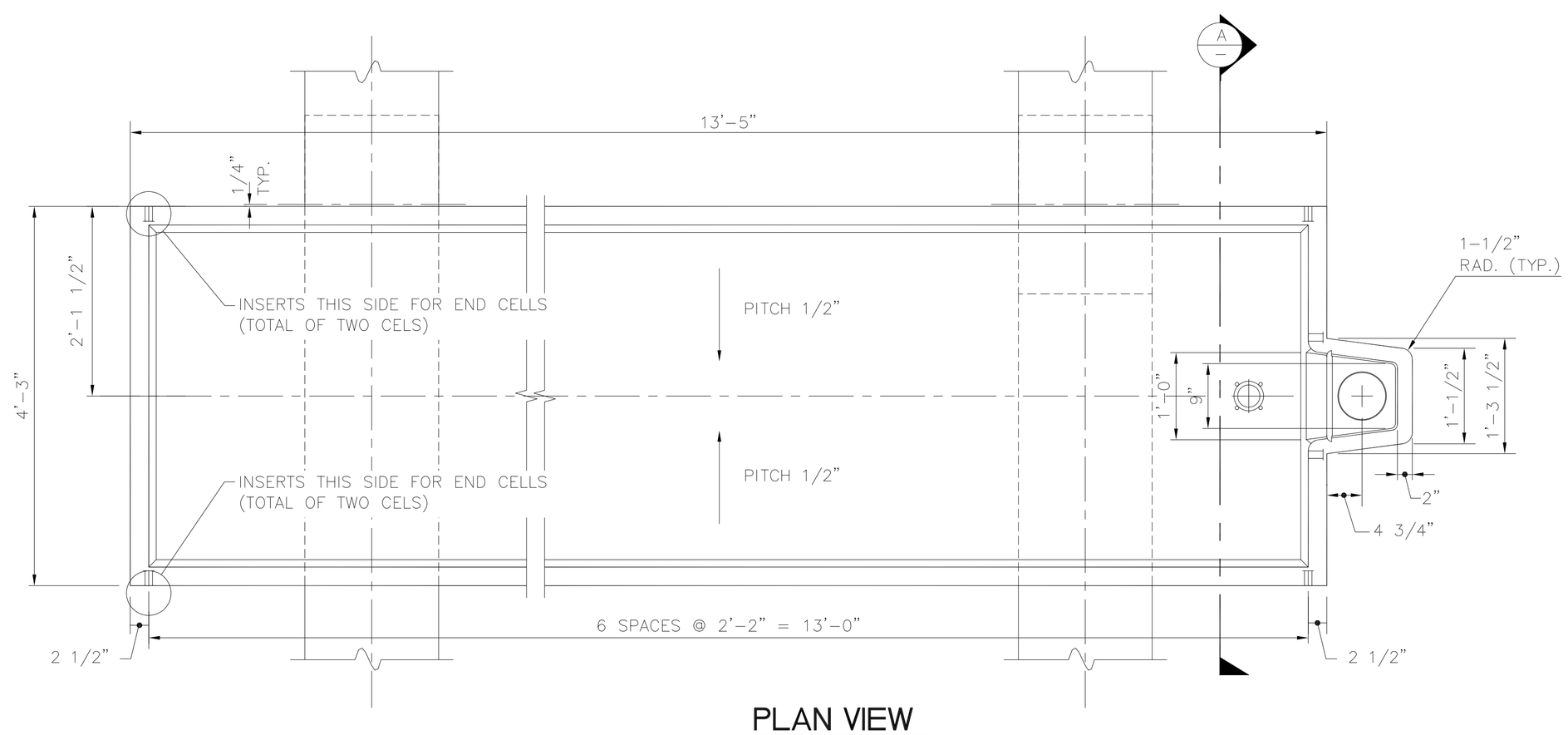
SIDE VIEW
SCALE: 1"=1'-0"



END VIEW
SCALE: 1"=1'-0"



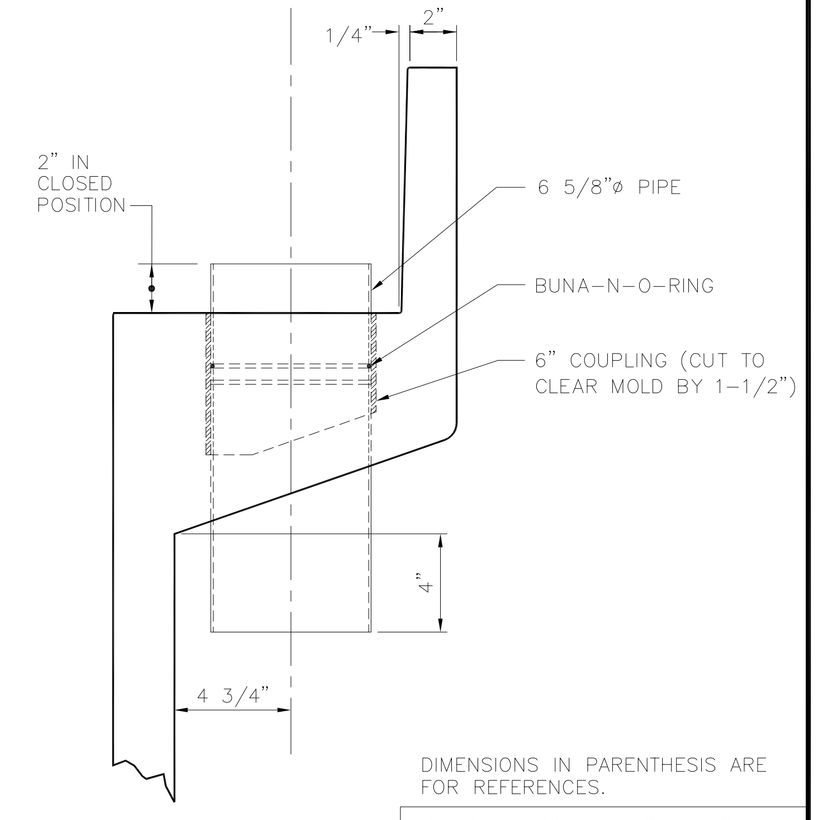
SECTION A
SCALE: 1"=1'-0"



PLAN VIEW
SCALE: 1"=1'-0"

GENERAL NOTES:

1. SUPPORT CELLS AT 1/4" POINTS DURING SHIPMENT AND STORAGE. SUPPORTS MUST BE LEVEL OR UNIFORM SO THE CELLS ARE NOT WARPED.
2. ESTIMATED WEIGHT OF UNICELL IS 10200 LBS.
3. ALL FLANGED CONNECTIONS TO UNICELL REQUIRE FULL FACE GASKETS WITH MAXIMUM 40 DUROMETER HARDNESS 4. WHEN USING CRANES AND FORKLIFT TO HANDLE THIS PRODUCT, USE SOFT PADS AND CORNER GUARDS TO PROTECT EDGES AND GELCOAT SURFACES.



DETAIL 1
SCALE: 2"=1'-0"

DIMENSIONS IN PARENTHESIS ARE FOR REFERENCES.

REFERENCE DRAWING: 40-CN-02
(OK MINE, ELECTROWINNING, CONCRETE, CELL DETAILS, PROJECT # 98010).

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CS Mining LLC

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QLTY. CONTROL					

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ENGR. MNGR.	

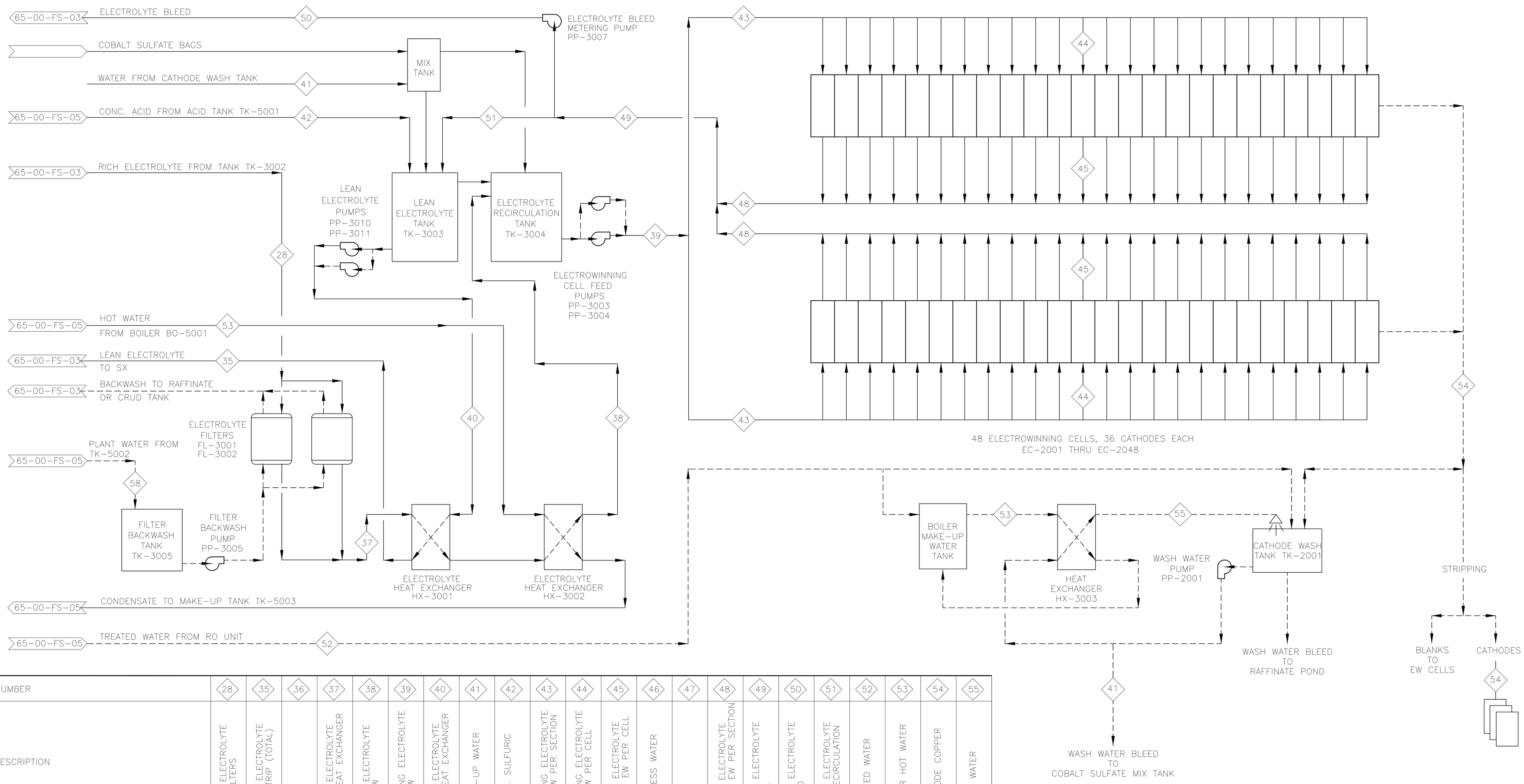
COPPER LEACH/CCD PROJECT - PHASE 1
SOLVENT EXTRACTION, ELECTROWINNING
ELECTROWINNING
POLYMER CONCRETE - CELL DETAILS

SCALE: AS NOTED

DRAWING NO. 40-CN-02

SHEET 1 OF 1

REVISION P1



STREAM NUMBER		28	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55
STREAM DESCRIPTION		RICH ELECTROLYTE TO FILTERS	LEAN ELECTROLYTE TO STRIP (TOTAL)		RICH ELECTROLYTE TO HEAT EXCHANGER	RICH ELECTROLYTE TO EW	STRONG ELECTROLYTE TO EW	LEAN ELECTROLYTE TO HEAT EXCHANGER	MAKE-UP WATER	CONC. SULFURIC ACID	STRONG ELECTROLYTE TO EW PER SECTION	STRONG ELECTROLYTE TO EW PER CELL	WEAK ELECTROLYTE FROM EW PER CELL	PROCESS WATER		WEAK ELECTROLYTE FROM EW PER SECTION	WEAK ELECTROLYTE TOTAL	WEAK ELECTROLYTE BLEED	WEAK ELECTROLYTE TO RECIRCULATION	TREATED WATER	BOILER HOT WATER	CATHODE COPPER	WASH WATER
STREAM MEDIUM																							
SPECIFIC GRAVITY		1.2	1.2		1.2	1.2	1.2	1.2	1.0	1.84	1.2	1.2	1.2			1.2	1.2	1.2	1.2				
FLOW RATE	U.S. GPM	370	370		370	370	1282	370	2.0	0.2	641	28.8	28.8			641	1382	2	1380	4	141		65
COPPER CONTENT	LBS/MIN	141.5	110.0		141.5	141.5	414	110	0.0	0.0		9.30	8.56					0.6				31.5	
	GPL	45	35		45	45	38	35	0.0	0.0	38	38	35			35	35	35	35				
ACID CONTENT	LBS/MIN								0.0	3.0		45.3	46.3					3.2					
	GPL	180	189		180	180	185	189	0.0			185	189				189	189	189				
DESIGN TEMPERATURE	°F	60	60		60	100	100	100				100	105				105		105	60	240		175

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COPPER LEACH/CCD PROJECT - PHASE 1
SOLVENT EXTRACTION, ELECTROWINNING

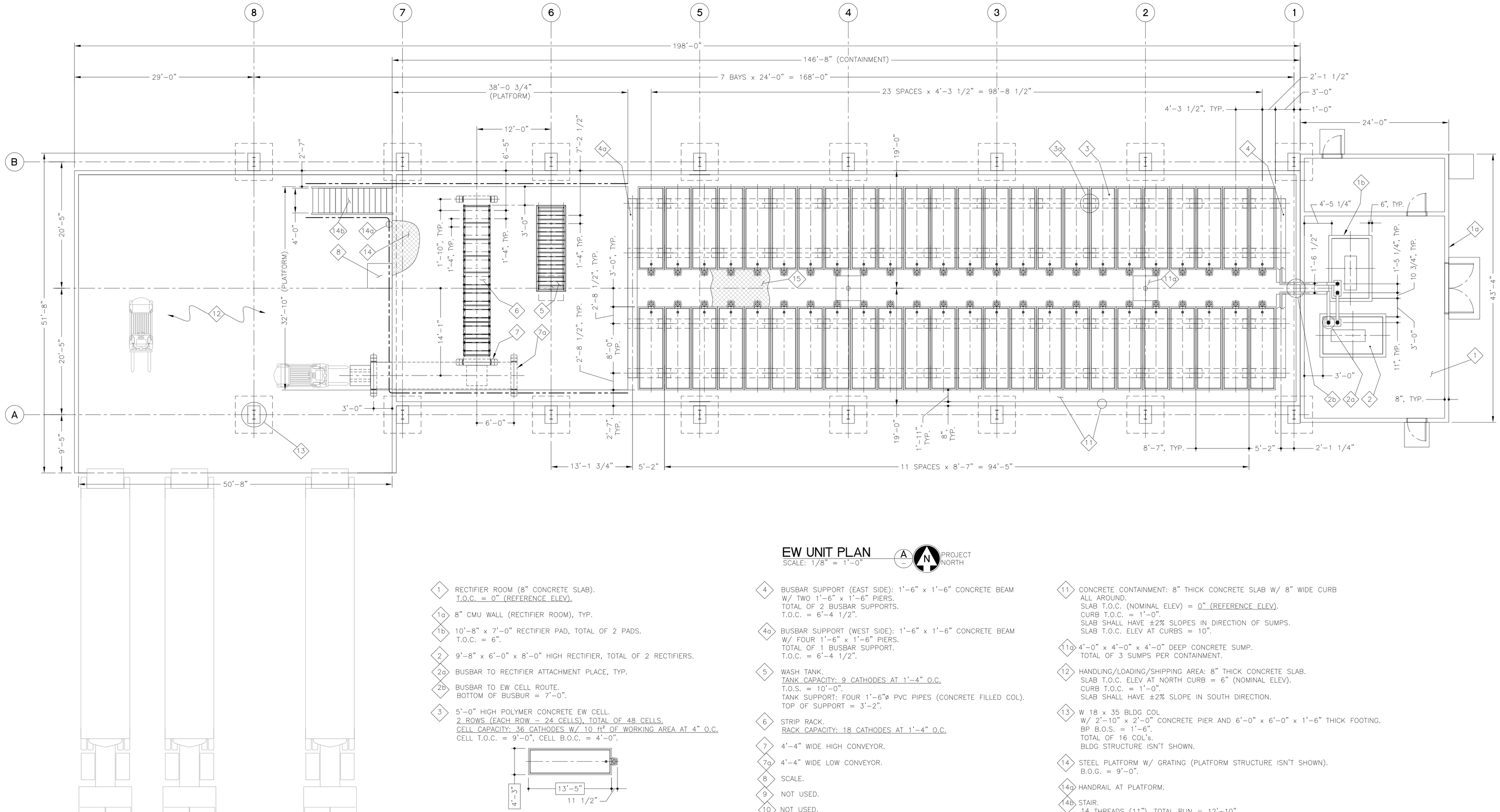
ELECTROWINNING FLOWSHEET

SCALE: AS NOTED

DRAWING NO. 40-FS-01

SHEET 1 OF 1

REVISION P1



EW UNIT PLAN

SCALE: 1/8" = 1'-0"

PROJECT NORTH

1. RECTIFIER ROOM (8" CONCRETE SLAB).
   T.O.C. = 0" (REFERENCE ELEV).

1a. 8" CMU WALL (RECTIFIER ROOM), TYP.

1b. 10'-8" x 7'-0" RECTIFIER PAD, TOTAL OF 2 PADS.
   T.O.C. = 6".

2. 9'-8" x 6'-0" x 8'-0" HIGH RECTIFIER, TOTAL OF 2 RECTIFIERS.

2a. BUSBAR TO RECTIFIER ATTACHMENT PLACE, TYP.

2b. BUSBAR TO EW CELL ROUTE.
   BOTTOM OF BUSBUR = 7'-0".

3. 5'-0" HIGH POLYMER CONCRETE EW CELL.
   2 ROWS (EACH ROW – 24 CELLS), TOTAL OF 48 CELLS.
   CELL CAPACITY: 36 CATHODES W/ 10 ft^2 OF WORKING AREA AT 4" O.C.
   CELL T.O.C. = 9'-0", CELL B.O.C. = 4'-0".

3a. EW CELLS ROW SUPPORT: 1'-6" WIDE x 2'-0" HIGH CONCRETE BEAM
   W/ TWELVE 2'-0" x 1'-6" PIERS,
   TWO BEAMS PER CELLS ROW.
   BEAM T.O.C. = 4'-0".

4. BUSBAR SUPPORT (EAST SIDE): 1'-6" x 1'-6" CONCRETE BEAM
   W/ TWO 1'-6" x 1'-6" PIERS.
   TOTAL OF 2 BUSBAR SUPPORTS.
   T.O.C. = 6'-4 1/2".

4a. BUSBAR SUPPORT (WEST SIDE): 1'-6" x 1'-6" CONCRETE BEAM
   W/ FOUR 1'-6" x 1'-6" PIERS.
   TOTAL OF 1 BUSBAR SUPPORT.
   T.O.C. = 6'-4 1/2".

5. WASH TANK.
   TANK CAPACITY: 9 CATHODES AT 1'-4" O.C.
   T.O.S. = 10'-0".
   TANK SUPPORT: FOUR 1'-6"ø PVC PIPES (CONCRETE FILLED COL).
   TOP OF SUPPORT = 3'-2".

6. STRIP RACK.
   RACK CAPACITY: 18 CATHODES AT 1'-4" O.C.

7. 4'-4" WIDE HIGH CONVEYOR.

7a. 4'-4" WIDE LOW CONVEYOR.

8. SCALE.

9. NOT USED.

10. NOT USED.

11. CONCRETE CONTAINMENT: 8" THICK CONCRETE SLAB W/ 8" WIDE CURB
   ALL AROUND.
   SLAB T.O.C. (NOMINAL ELEV) = 0" (REFERENCE ELEV).
   CURB T.O.C. = 1'-0".
   SLAB SHALL HAVE ±2% SLOPES IN DIRECTION OF SUMPS.
   SLAB T.O.C. ELEV AT CURBS = 10".

11a. 4'-0" x 4'-0" x 4'-0" DEEP CONCRETE SUMP.
   TOTAL OF 3 SUMPS PER CONTAINMENT.

12. HANDLING/LOADING/SHIPPING AREA: 8" THICK CONCRETE SLAB.
   SLAB T.O.C. ELEV AT NORTH CURB = 6" (NOMINAL ELEV).
   CURB T.O.C. = 1'-0".
   SLAB SHALL HAVE ±2% SLOPE IN SOUTH DIRECTION.

13. W 18 x 35 BLDG COL
   W/ 2'-10" x 2'-0" CONCRETE PIER AND 6'-0" x 6'-0" x 1'-6" THICK FOOTING.
   BP B.O.S. = 1'-6".
   TOTAL OF 16 COL's.
   BLDG STRUCTURE ISN'T SHOWN.

14. STEEL PLATFORM W/ GRATING (PLATFORM STRUCTURE ISN'T SHOWN).
   B.O.G. = 9'-0".

14a. HANDRAIL AT PLATFORM.

14b. STAIR.
   14 THREADS (11"), TOTAL RUN = 12'-10",
   15 RISERS (7"), TOTAL RISE 8'-9"
   (STAIR T.O.G. = 9'-2", SLAB AT STAIR T.O.C. = ±5").

15. GRATING AT EW CELLS AREA (GRATING SUPPORT ISN'T SHOWN).
   B.O.G. = 9'-0".

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COPPER LEACH/CCD PROJECT - PHASE 1
SOLVENT EXTRACTION, ELECTROWINNING

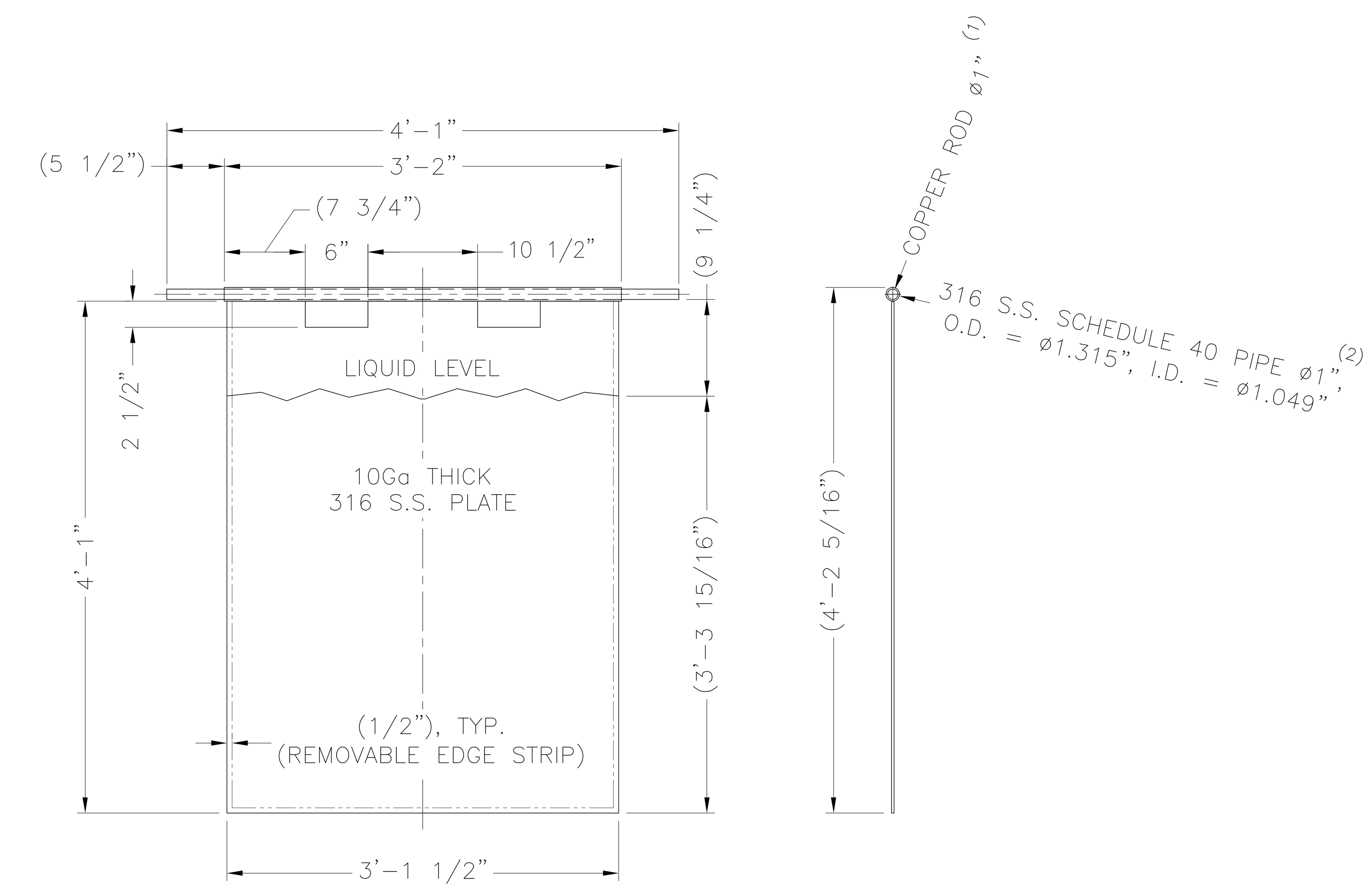
ELECTROWINNING
UNIT LAYOUT

SCALE: AS NOTED

DRAWING NO. 40-GA-01

SHEET 1 OF 1

REVISION P1



CATHODE ASSEMBLY

SCALE: 1"=1'-0"

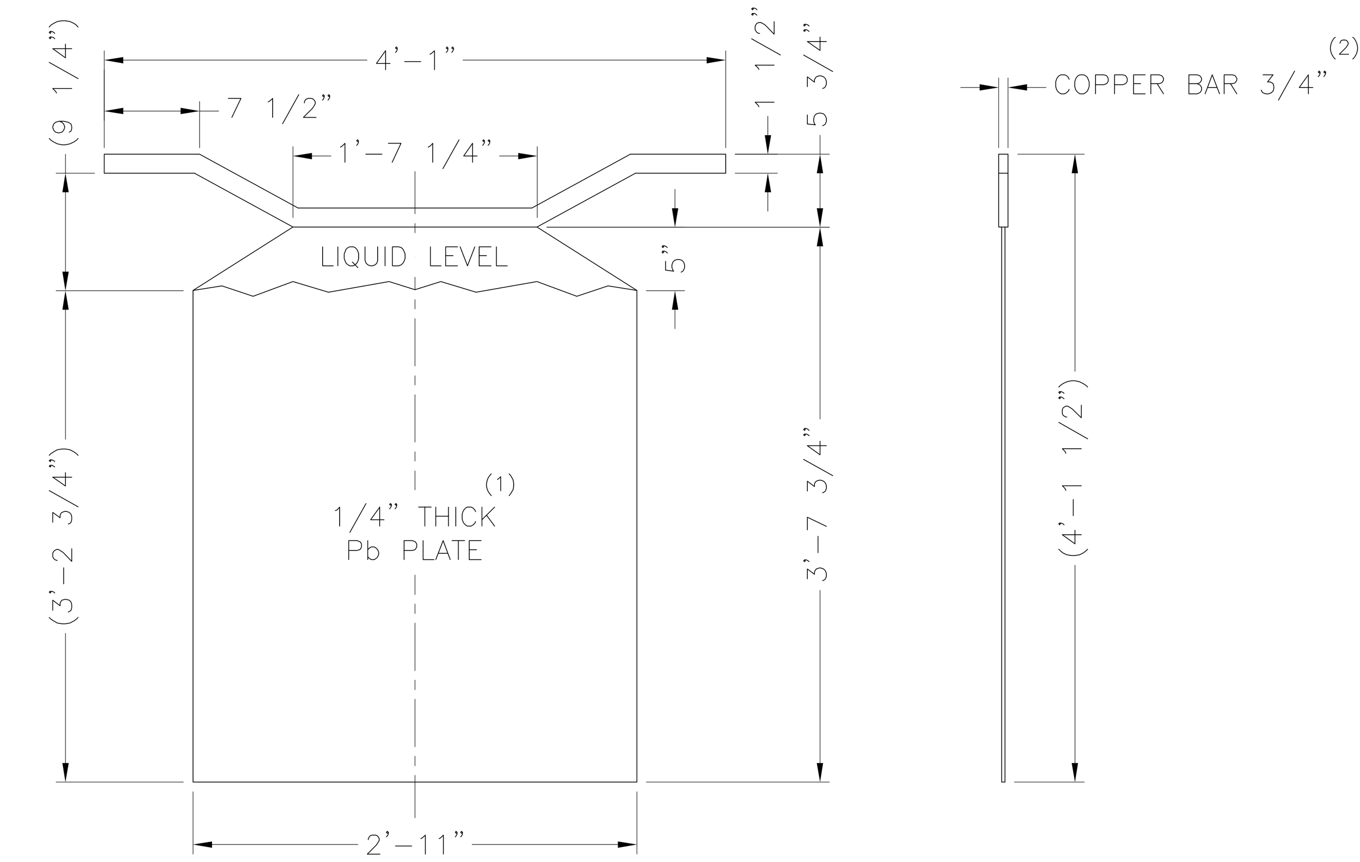
DIMENSIONS IN PARENTHESIS ARE FOR REFERENCES.

– – – – – – – – LIMIT OF REMOVABLE EDGE STRIP.

CATHODE WORKING AREA: 10 FT^2.

(1) COPPER ROD: PRESSED IN PIPE. PIPE THEN CRIMP FLATTENED OVER ENTIRE CATHODE PLATE WIDTH.

(2) PIPE TO PLATE ATTACHMENT: 1/8" CONTINUOUS, BOTH SIDES, FILLET WELD.



Pb ANODE ASSEMBLY

SCALE: 1"=1'-0"

DIMENSIONS IN PARENTHESIS ARE FOR REFERENCES.

PROVIDE FIVE ANODE BUTTONS FROM NON-CONDUCTIVE MATERIAL IN CORNERS AND CENTER OF PLATE.

(1) Pb PLATE SPECIFICATION: 0.05% ... 0.1% Ca,
1.25% ... 1.75% Sb,
0.005% ... 0.02% Al.

(2) COPPER BAR W/ 6% Sb-Pb OVERCAST ON PLATE FOR ATTACHMENT.

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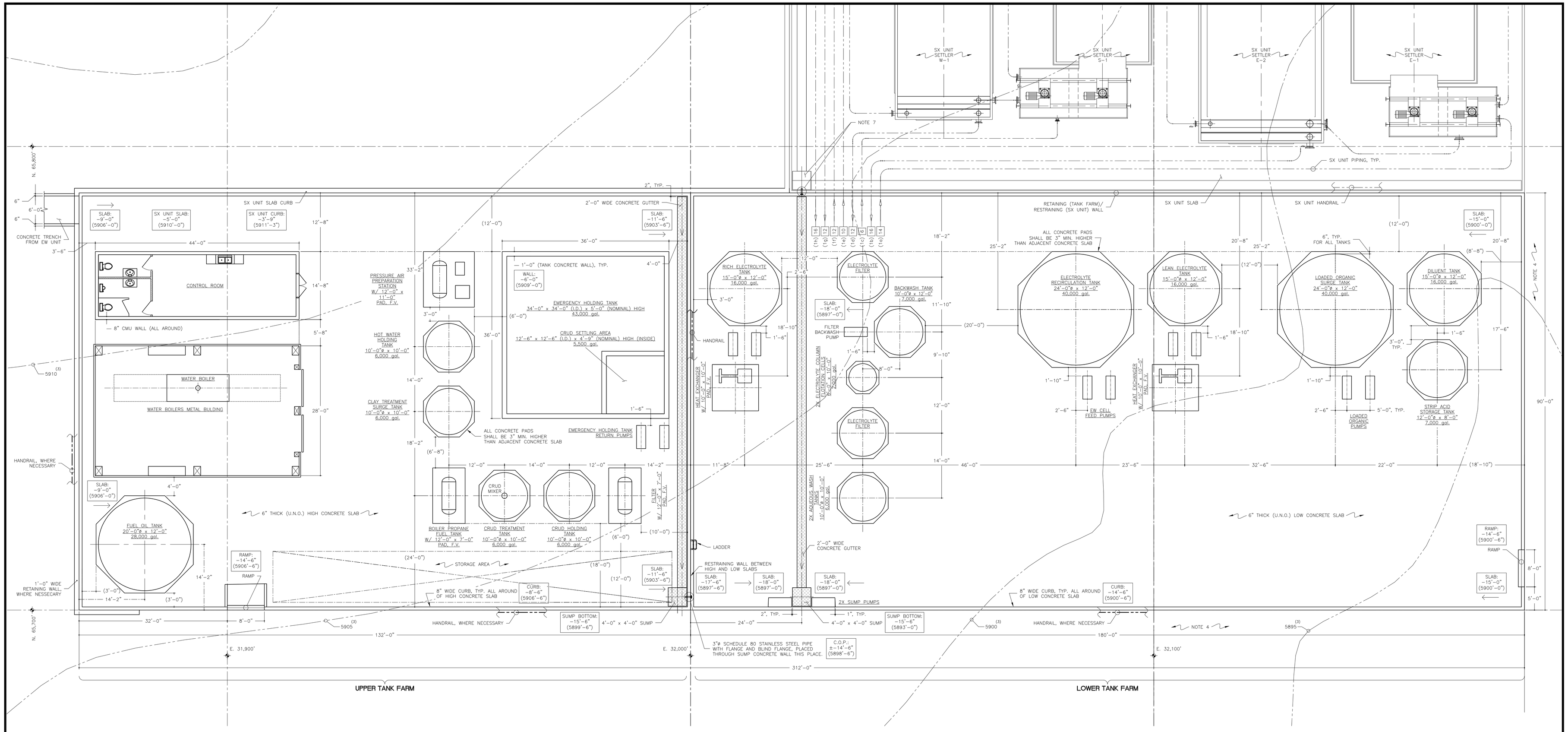
COPPER LEACH/CCD PROJECT - PHASE 1
SOLVENT EXTRACTION, ELECTROWINNING
ELECTROWINNING
MECHANICAL - CATHODE AND ANODE DETAILS

SCALE: AS NOTED

DRAWING NO. 40-M-02

SHEET 1 OF 1

REVISION P1



TANK FARM PLAN

SCALE: 1" = 10'-0"

PROJECT NORTH

F.V. ALL DIMENSIONS AND E. CONDITIONS.

DIMENSIONS IN PARENTHESIS ARE FOR REFERENCE.

TOPOGRAPHY DATA FROM OVERALL MAP FOR WESTERN UTAH COPPER CO. BY PLATT AND PLATT, INC. (DATE: NOVEMBER 2008, DRAWING: NAMtopoGRID.dwg).

TOP OF ALL SETTLERS 6" THICK CONCRETE BOTTOM (SX UNIT) = **0'-0" (REF ELEV)** = ±5915'.

⟶ – SLAB SLOPE.

SLAB: -9'-0" (5906'-0") – ITEM NAME – ELEV – ABSOLUTE ELEV.

↓ – TRENCH SLOPE.

——●—— – PIPE LINE/PIPE LINE FLOW DIRECTION (SX UNIT), TYP.

10 – PIPE DIAMETER, INCHES.

BOTTOM OF ALL PIPES AT CONCRETE CURB OF SX UNIT ELEV = -3'-9" MAX. (5911'-3").

(1) SEE NOTES 1o THROUGH 1h FOR PIPE LINE SOURCE/DESTINATION INFORMATION:

- (1o) FROM PLS POND,
- (1b) TO RAFFINATE POND,
- (1c) FROM LEAN ELECTROLYTE TANK,
- (1d) TO AQUEOUS WASH TANK,
- (1e) FROM AQUEOUS WASH TANK,
- (1f) FROM LOADED ORGANIC TANK,
- (1g) TO RICH ELECTROLYTE TANK,
- (1h) TO LOADED ORGANIC TANK.

(3) GROUND CONTOUR ELEVATION, FEET.

(4) TOP OF SOIL (ADJACENT TO TANK FARM SLABS) AT SOUTH AND EAST SIDES SHALL BE 1'-0" MAX. BELOW TOP OF CONCRETE CURB.
BERM AT THESE PLACES (IF NECESSARY) SHALL BE CONSTRUCTED OF SOIL REMOVED FROM BOTTOM OF CONCRETE SLABS.
THE SLOPE OF ALL NEW EMBANKMENTS SHALL BE LIMITED TO A RATIO OF 3:1.
TOP OF SOIL AT RAMPS (SOUTH SIDE AND EAST SIDE) SHALL BE 6" MAX. BELOW TOP OF CONCRETE RAMP.

PRELIMINARY
NOT FOR CONSTRUCTION
11-06-2013

TOLERANCE UNLESS OTHERWISE SPECIFIED: FRACTIONS ±; 0.00 ±; 0.000 ±

REVISIONS (DESTROY ALL PRINTS OF AN EARLIER DATE THAN LATEST REVISION)

REV	DESCRIPTION	BY	DATE
P1	FIRST REVIEW	HM	12/06/13

REV	DESCRIPTION	BY	DATE

CS Mining LLC

PROJECT NO 2012-01

WESTERN STATES ENGINEERING
5210 E. Williams Circle, Suite 700
TUCSON, AZ 85711
PHONE: 520-889-2040 FAX: 520-889-2733

APPROVED FOR CONSTRUCTION	BY	DATE		BY	DATE
SAFETY			PROCESS ENGR.		
ENVIRONMENTAL			PROJECT ENGR.		
MAINTENANCE			ENGR. MNGR.		
PRODUCTION			PLANT MNGR.		
QLTY. CONTROL					

DESIGN		DATE
DRAWN BY	AM	11/06/13
PROJ. ENGR.	HM	
ENGR. MNGR.		

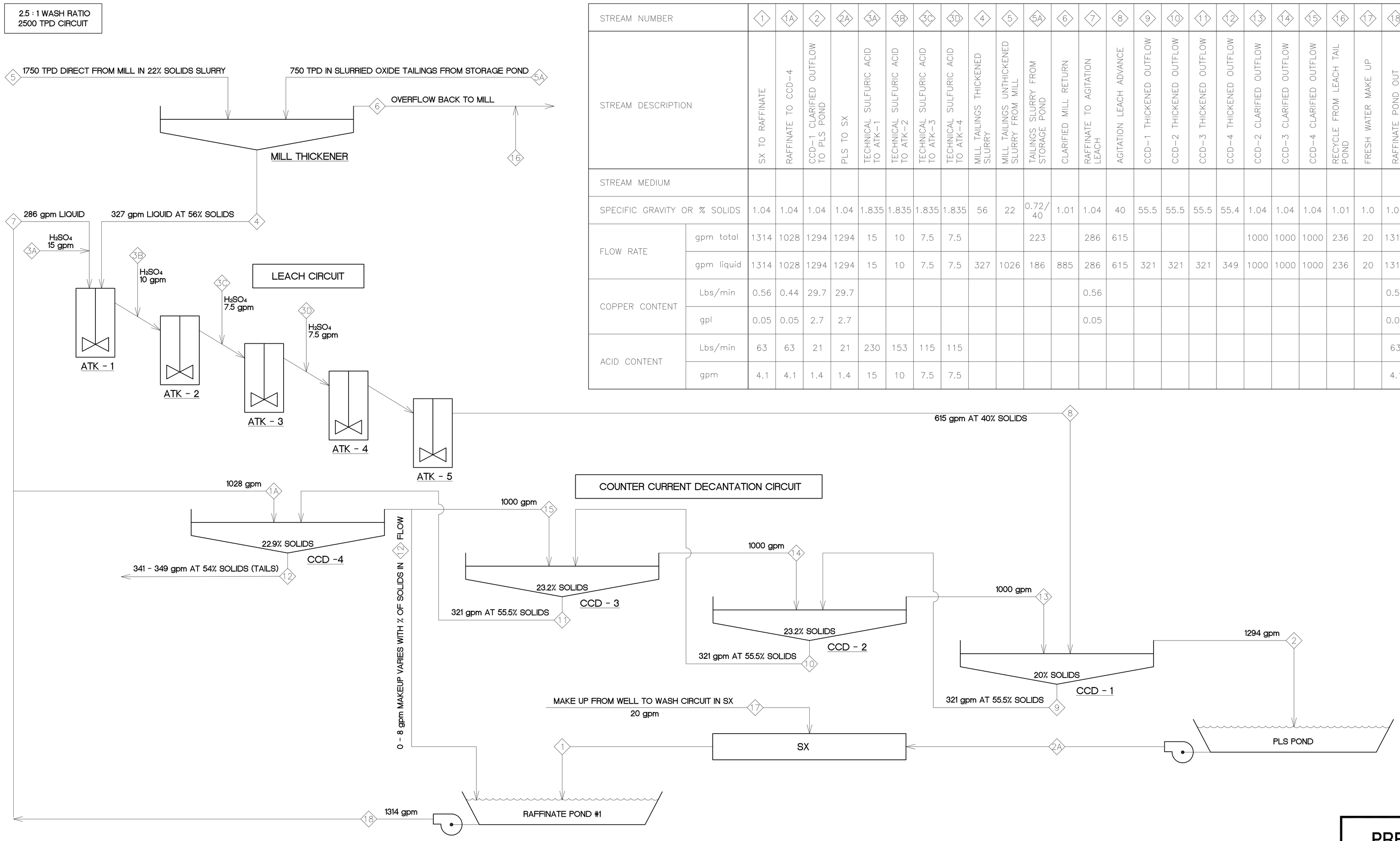
COPPER LEACH/CCD PROJECT - PHASE 1
SOLVENT EXTRACTION, ELECTROWINNING
TANK FARM
UNIT LAYOUT

SCALE: AS NOTED

DRAWING NO. 50-GA-01

SHEET 1 OF 1

REVISION P1



STREAM NUMBER		1	1A	2	2A	3A	3B	3C	3D	4	5	5A	6	7	8	9	10	11	12	13	14	15	16	17	18
STREAM DESCRIPTION		SX TO RAFFINATE	RAFFINATE TO CCD-4	CCD-1 CLARIFIED OUTFLOW TO PLS POND	PLS TO SX	TECHNICAL SULFURIC ACID TO ATK-1	TECHNICAL SULFURIC ACID TO ATK-2	TECHNICAL SULFURIC ACID TO ATK-3	TECHNICAL SULFURIC ACID TO ATK-4	MILL TAILINGS THICKENED SLURRY	MILL TAILINGS UNTHICKENED SLURRY FROM MILL	TAILINGS SLURRY FROM STORAGE POND	CLARIFIED MILL RETURN	RAFFINATE TO AGITATION LEACH	AGITATION LEACH ADVANCE	CCD-1 THICKENED OUTFLOW	CCD-2 THICKENED OUTFLOW	CCD-3 THICKENED OUTFLOW	CCD-4 THICKENED OUTFLOW	CCD-2 CLARIFIED OUTFLOW	CCD-3 CLARIFIED OUTFLOW	CCD-4 CLARIFIED OUTFLOW	RECYCLE FROM LEACH TAIL POND	FRESH WATER MAKE UP	RAFFINATE POND OUT
STREAM MEDIUM																									
SPECIFIC GRAVITY OR % SOLIDS		1.04	1.04	1.04	1.04	1.835	1.835	1.835	1.835	56	22	0.72/40	1.01	1.04	40	55.5	55.5	55.5	55.4	1.04	1.04	1.04	1.01	1.0	1.04
FLOW RATE	gpm total	1314	1028	1294	1294	15	10	7.5	7.5			223		286	615					1000	1000	1000	236	20	1314
	gpm liquid	1314	1028	1294	1294	15	10	7.5	7.5	327	1026	186	885	286	615	321	321	321	349	1000	1000	1000	236	20	1314
COPPER CONTENT	Lbs/min	0.56	0.44	29.7	29.7									0.56											0.56
	gpl	0.05	0.05	2.7	2.7									0.05											0.05
ACID CONTENT	Lbs/min	63	63	21	21	230	153	115	115																63
	gpm	4.1	4.1	1.4	1.4	15	10	7.5	7.5																4.1

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TOLERANCE UNLESS OTHERWISE SPECIFIED — FRACTIONS ± ; 0.00 ± ; 0.000 ±

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QLTY. CONTROL					

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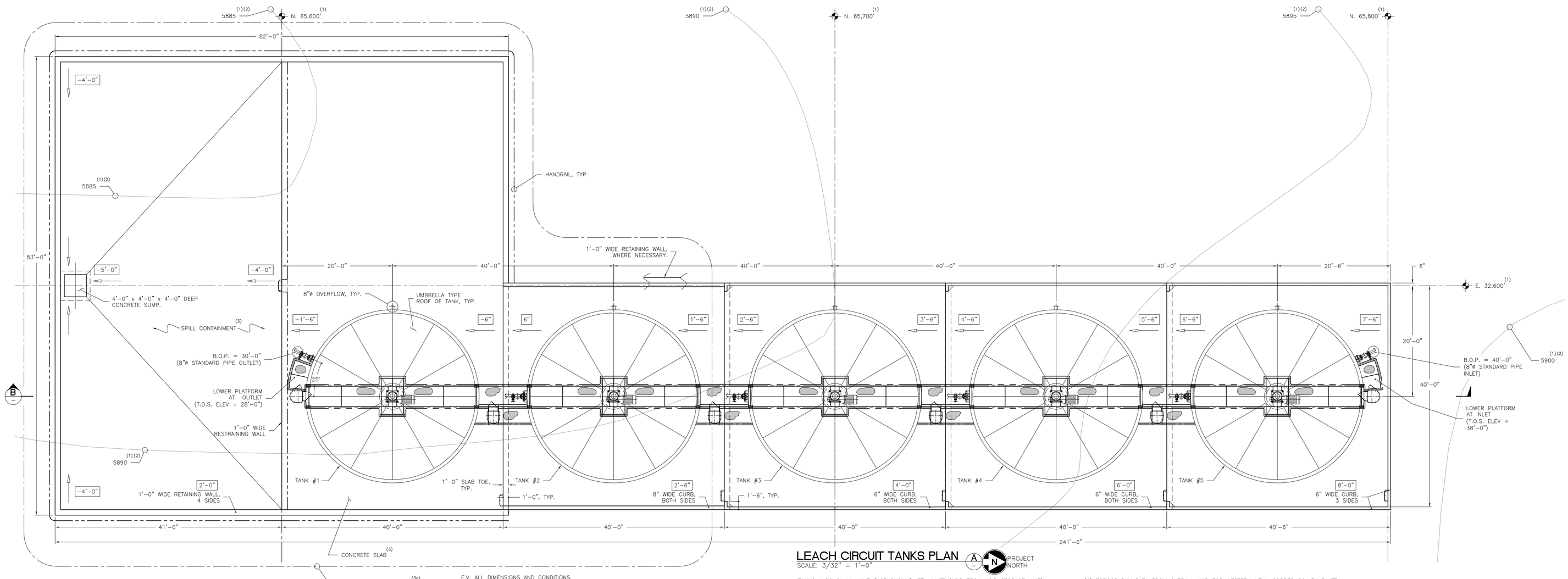
COPPER LEACH/CCD PROJECT - PHASE 1
SOLVENT EXTRACTION, ELECTROWINNING
LEACH CIRCUIT TANKS/CCD
FLOWSHEET

SCALE: AS NOTED

DRAWING NO. 60-FS-01

SHEET 1 OF 1

REVISION P1



LEACH CIRCUIT TANKS PLAN

SCALE: 3/32" = 1'-0"

PROJECT NORTH

F.V. ALL DIMENSIONS AND CONDITIONS.

LEACH CIRCUIT TANKS SHALL BE: 30'-0"ø, 34'-0" HIGH (TOP OF UPPER ROLLED SKIRT ANGLE).
TANKS SHALL HAVE UMBRELLA TYPE ROOF W/ STRUCTURAL SUPPORT FOR PLATFORM AND AGITATOR UNIT.
LIQUID LEVEL SHALL BE 30'-0" ABOVE TANK BOTTOM.
TANKS SHALL HAVE: 8"ø PIPE FLANGED INLET (B.O.P. = 32'-0" ABOVE TANK BOTTOM).
8"ø PIPE FLANGED OUTLET (B.O.P. = 30'-0" ABOVE TANK BOTTOM).
LIQUID TAKE-OFF FOR TANK OUTLET SHALL BE AT 10'-0" ABOVE TANK BOTTOM.
8"ø PIPE FLANGED OVERFLOW OUTLET (B.O.P. = 33'-0" ABOVE TANK BOTTOM).
TANK MATERIAL: 316 SS.
TANK VOLUME: ±21 THOUSANDS CUBIC FEET (OUTLET LEVEL)
±23 THOUSANDS CUBIC FEET (OVERFLOW LEVEL).
SPILL CONTAINMENT VOLUME: ±29 THOUSANDS CUBIC FEET.

TANKS ALSO SHALL HAVE (NOT SHOWN): 3"ø INLET (ACID FROM ACID STORAGE UNIT) (B.O.P. = 33'-0" ABOVE TANK BOTTOM).
MANHOLE (LOCATION AT OWNER DISCRETION).
ROOF VENT GOOSE NECK.
FLUSH TYPE CLEANOUT (NOT SHOWN).

REF ELEV = 0'-0" = 5890' (T.O.C. OF TANK #1 PAD – SEE SECTION B.

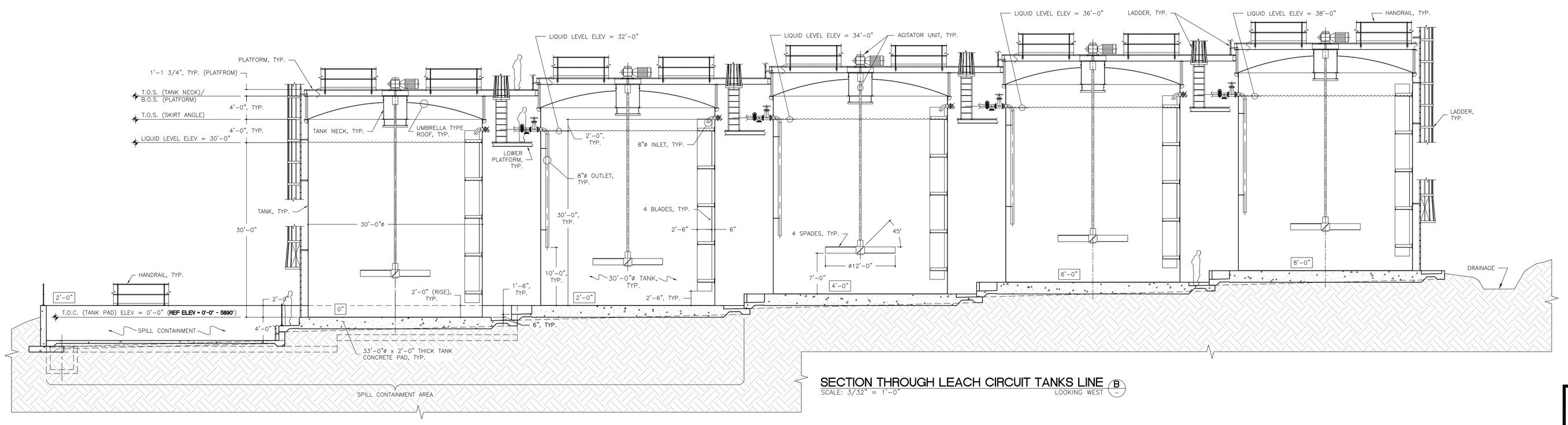
1'-6" – T.O.C. ELEV.

(1) TOPOGRAPHY DATA FROM OVERALL MAP FOR WESTERN UTAH COPPER CO. BY PLATT AND PLATT, INC. (DATE: NOVEMBER 2008, DRAWING: NAMtopoGRID.dwg).

(2) GROUND CONTOUR ELEVATION, FEET (SEE NOTE 1).

(3) 6" THICK CONCRETE SLAB AREA (FIVE STEPS AT 2'-0" RISE AND SPILL CONTAINMENT AS SHOWN).
– SLAB SLOPE.

(3a) SPILL CONTAINMENT AREA (INCLUDES SPILL CONTAIMENT AND FIRST TWO STEPS OF SLAB AREA).



SECTION THROUGH LEACH CIRCUIT TANKS LINE (B)

SCALE: 3/32" = 1'-0"

LOOKING WEST

PRELIMINARY
NOT FOR CONSTRUCTION
11-06-2013

TOLERANCE UNLESS OTHERWISE SPECIFIED
FRACTIONS ±
0.00 ±
0.000 ±

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ENVIRONMENTAL			PROJECT ENGR.		
MAINTENANCE			ENGR. MNGR.		
PRODUCTION			PLANT MNGR.		
QLTY. CONTROL					

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ENGR. MNGR.		

COPPER LEACH/CCD PROJECT - PHASE 1
SOLVENT EXTRACTION, ELECTROWINNING

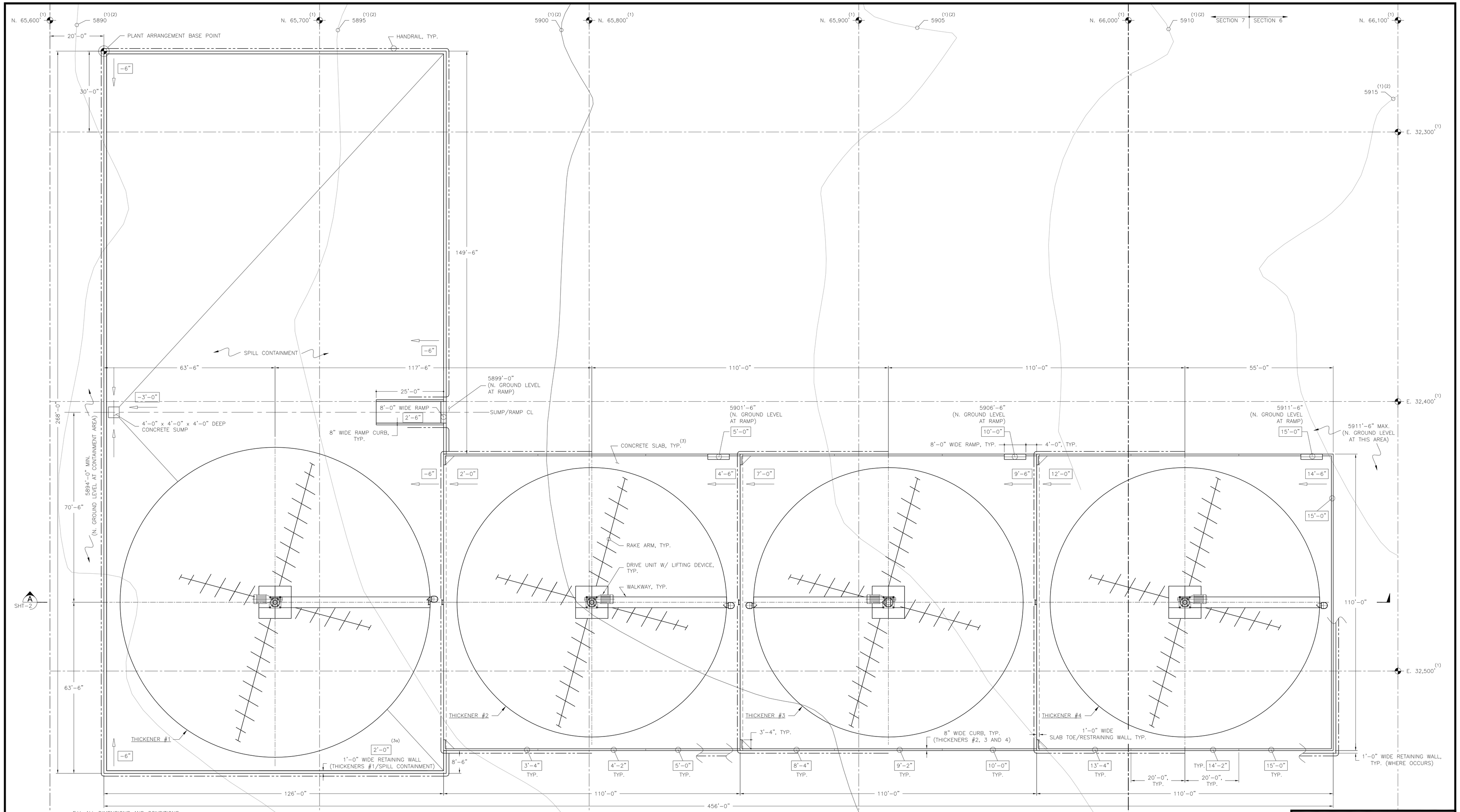
LEACH CIRCUIT TANKS/CCD
LEACH CIRCUIT TANKS LAYOUT

SCALE: AS NOTED

DRAWING NO. 60-GA-01

SHEET 1 OF X

REVISION P1



F.V. ALL DIMENSIONS AND CONDITIONS.

CCD CIRCUIT THICKENERS SCHEMATIC PROFILES ARE SHOWN.
THICKENERS #1 SHALL BE: 115'-0"ø, THICKENERS #2, 3 AND 4 SHALL BE: 100'-0"ø.
THICKENERS MATERIAL: 316 SS.

THICKENER #1 VOLUME: ±100 THOUSANDS CUBIC FEET,
SPILL CONTAINMENT VOLUME: ±120 THOUSANDS CUBIC FEET.

THICKENERS BRIDGES AREN'T SHOWN.

REF ELEV = 0'-0" = 5897' (B.O.S. OF THICKENERS #1 SUPPORT COL's BP).

1'-6" – T.O.C. ELEV.

PIPING ISN'T SHOWN.

CCD THICKENERS CIRCUIT PLAN

SCALE: 1/16" = 1'-0"

PROJECT NORTH

(1) TOPOGRAPHY DATA FROM OVERALL MAP FOR WESTERN UTAH COPPER CO. BY PLATT AND PLATT, INC. (DATE: NOVEMBER 2008, DRAWING: NAMtopoGRID.dwg).

(2) GROUND CONTOUR ELEVATION, FEET (SEE NOTE 1).

(3) 6" THICK CONCRETE SLAB (FOUR STEPS AT 5'-0" NOMINAL RISE).
– SLAB SLOPE.

(3a) TOP OF RETAINING WALL (SPILL CONTAINMENT AREA).

PRELIMINARY
NOT FOR CONSTRUCTION
11-06-2013

TOLERANCE UNLESS OTHERWISE SPECIFIED		
FRACTIONS	±	
0.00	±	
0.000	±	

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MAINTENANCE			ENGR. MNGR.		
PRODUCTION			PLANT MNGR.		
QLTY. CONTROL					

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COPPER LEACH/CCD PROJECT - PHASE 1
SOLVENT EXTRACTION, ELECTROWINNING

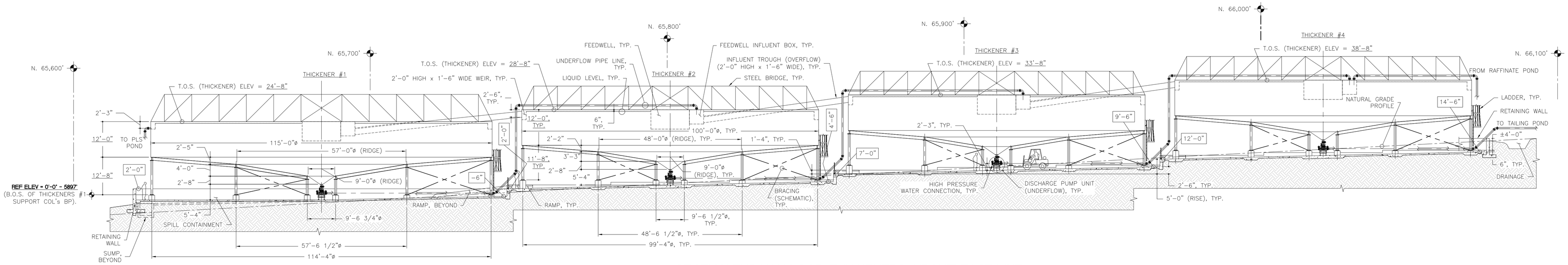
LEACH CIRCUIT TANKS/CCD
CCD THICKENERS CIRCUIT LAYOUT

SCALE: AS NOTED

DRAWING NO. 61-GA-01

SHEET 1 OF X

REVISION P1



SECTION THROUGH CCD THICKENERS CIRCUIT EAST LINE (A SHT-1)

SCALE: 1/16" = 1'-0" LOOKING WEST

SEE PLAN A/SHT-1 FOR INFORMATION NOT SHOWN.

DRIVE UNIT W/ LIFTING DEVICE, RAKE ARMS AREN'T SHOWN.

THICKENERS BOTTOM SLOPES: EXTERNAL CIRCLE AT 1 : 12,
INTERNAL CIRCLE AT 2 : 12,
DISCHARGE CONE AT 1 : 1.

PRELIMINARY
NOT FOR CONSTRUCTION
11-06-2013

TOLERANCE UNLESS OTHERWISE SPECIFIED: FRACTIONS ±, 0.00 ±, 0.000 ±

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PRODUCTION			PLANT MNGR.		
QLTY. CONTROL					

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COPPER LEACH/CCD PROJECT - PHASE 1
SOLVENT EXTRACTION, ELECTROWINNING

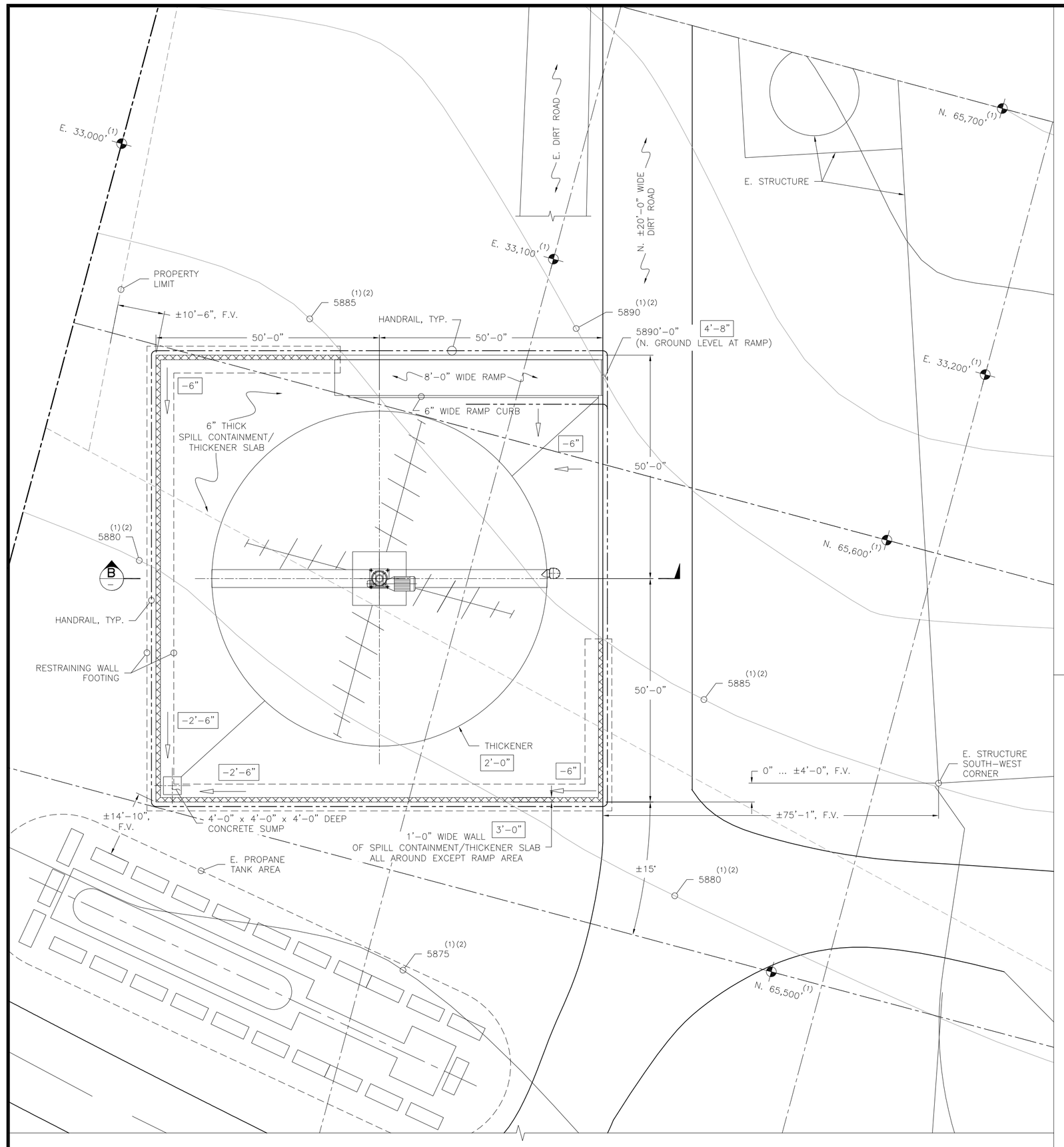
LEACH CIRCUIT TANKS/CCD
CCD THICKENERS CIRCUIT SECTION

SCALE: AS NOTED

DRAWING NO. 61-GA-01

SHEET 2 OF X

REVISION P1



MILL THICKENER PLAN (A)

SCALE: 1/16" = 1'-0"

PROJECT NORTH

F.V. ALL DIMENSIONS AND CONDITIONS.

MILL THICKENER SCHEMATIC PROFILE IS SHOWN.

THICKENER BRIDGE ISN'T SHOWN.

THICKENERS SHALL BE: 75'-0"ø.
THICKENERS MATERIAL: 316 SS.

THICKENER VOLUME: ±36 THOUSANDS CUBIC FEET,
SPILL CONTAINMENT VOLUME: ±43 THOUSANDS CUBIC FEET.

REF ELEV = 0'-0" = 5887' (B.O.S. OF THICKENER SUPPORT COL's BP).

1'-6" – T.O.C./TOP OF GROUND LEVEL ELEV.

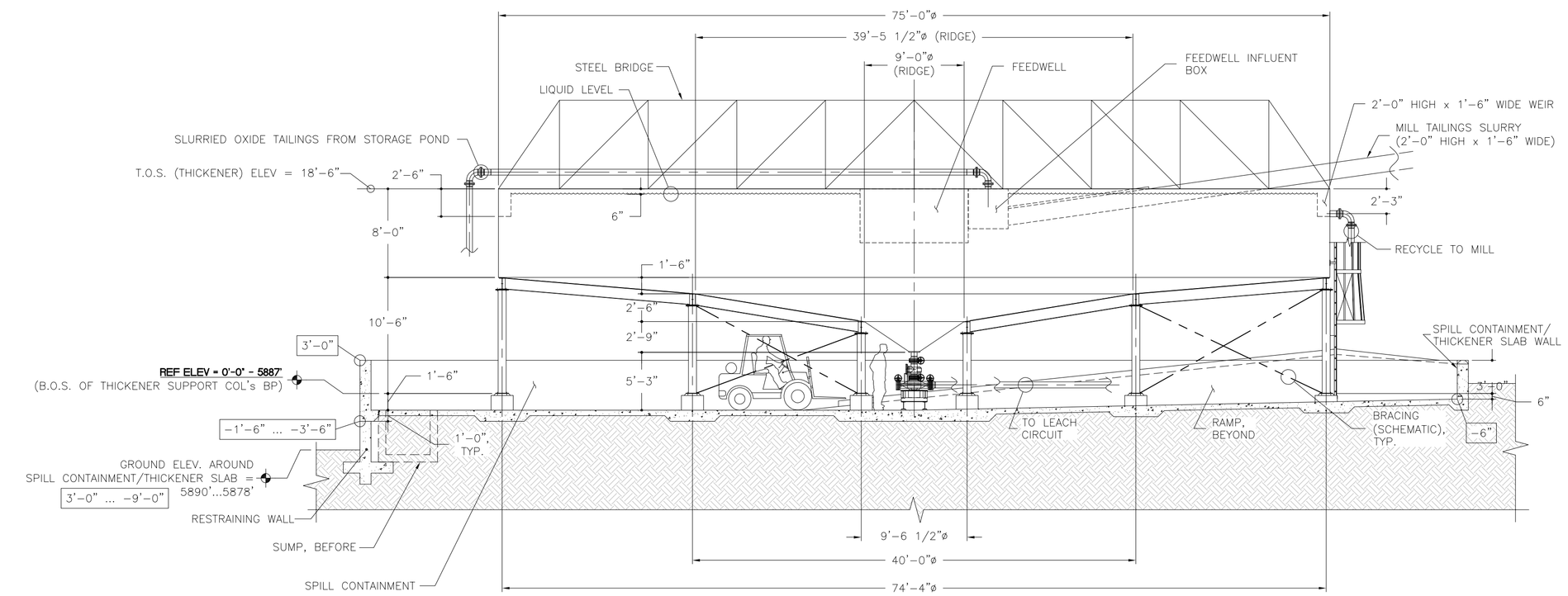
– SLAB SLOPE.

– RESTRAINING WALL BELOW (UNDER SLAB). F.V. WALL CONTINUATION.

PIPING ISN'T SHOWN.

(1) TOPOGRAPHY DATA FROM OVERALL MAP FOR WESTERN UTAH COPPER CO. BY PLATT AND PLATT, INC. (DATE: NOVEMBER 2008, DRAWING: NAMtopoGRID.dwg).

(2) GROUND CONTOUR ELEVATION, FEET (SEE NOTE 1).



SECTION THROUGH THICKENER (B)

SCALE: 1/8" = 1'-0" LOOKING NORTH-WEST

DRIVE UNIT W/ LIFTING DEVICE, RAKE ARMS AREN'T SHOWN.

THICKENER BOTTOM SLOPES: EXTERNAL CIRCLE AT 1 : 12,
INTERNAL CIRCLE AT 2 : 12,
DISCHARGE CONE AT 1 : 1.

PRELIMINARY
NOT FOR CONSTRUCTION
11-06-2013

TOLERANCE UNLESS OTHERWISE SPECIFIED: FRACTIONS ±, 0.00 ±, 0.000 ±

CS Mining LLC

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QLTY. CONTROL					

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COPPER LEACH/CCD PROJECT - PHASE 1
SOLVENT EXTRACTION, ELECTROWINNING

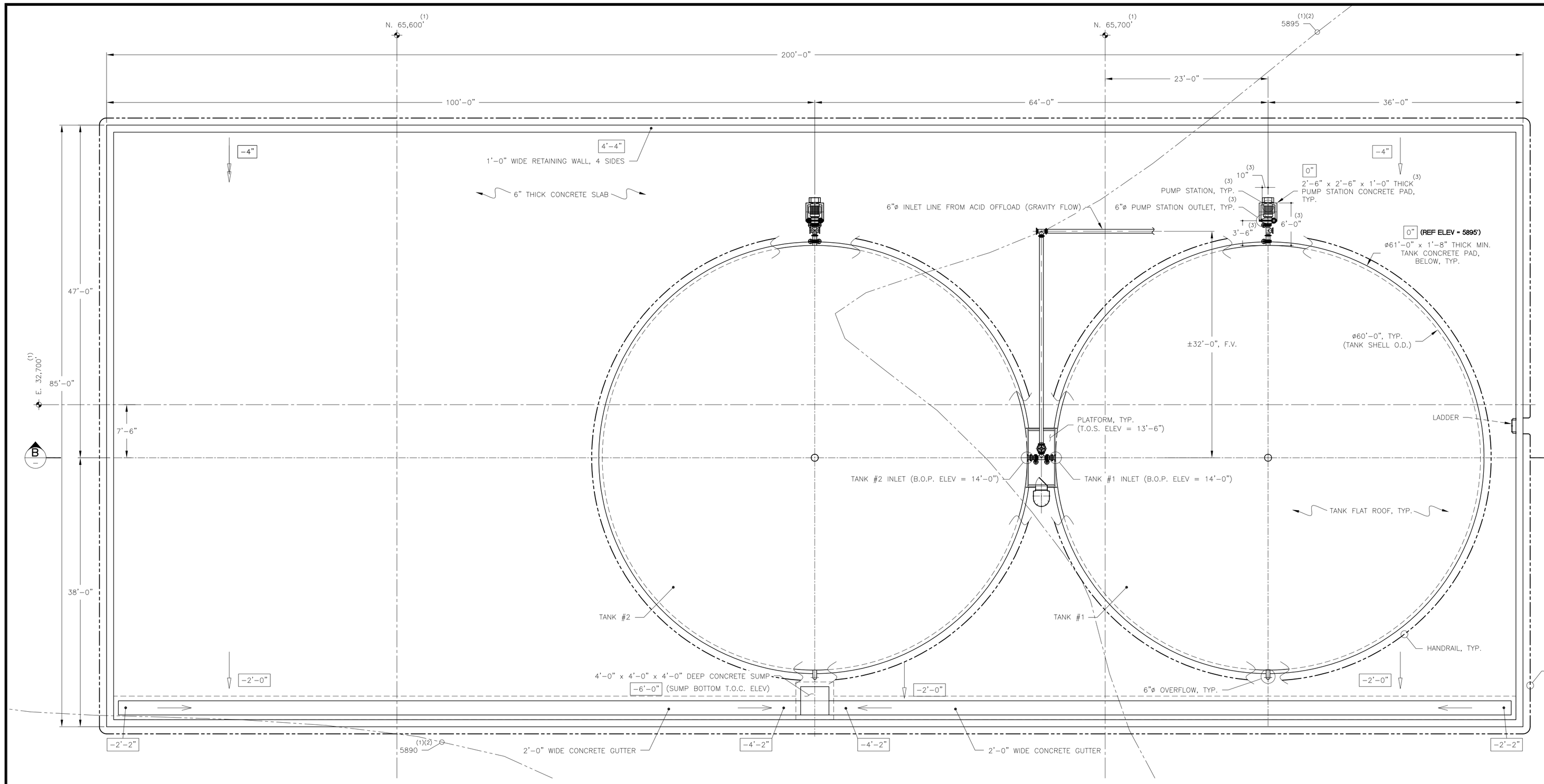
LEACH CIRCUIT TANKS/CCD
MILL THICKENER LAYOUT

SCALE: AS NOTED

DRAWING NO. 63-GA-01

SHEET 1 OF 1

REVISION P1



ACID STORAGE UNIT PLAN

SCALE: 1/8" = 1'-0"

A — PROJECT NORTH

F.V. ALL DIMENSIONS AND CONDITIONS.

ACID STORAGE TANKS SHALL BE: 60'-0"ø, 16'-0" HIGH (TOP OF UPPER ROLLED SKIRT ANGLE).
TANKS SHALL HAVE CONE OR FLAT TYPE ROOF W/ STRUCTURAL SUPPORT.
ACID LEVEL SHALL BE 14'-0" MAX. ABOVE TANK BOTTOM.
TANK VOLUME: ±40 THOUSANDS CUBIC FEET (OVERFLOW LEVEL).
SPILL CONTAINMENT VOLUME: ±46 THOUSANDS CUBIC FEET.
TANKS SHALL HAVE: 6"ø PIPE FLANGED INLET (B.O.P. ELEV = 14'-0" ABOVE TANK BOTTOM).
6"ø PIPE FLANGED OUTLET (COORDINATE B.O.P. W/ PUMP STATION).
6"ø PIPE FLANGED TANKS CONNECTION (C.O.P. ELEV = 2'-0" ABOVE TANK BOTTOM)..
6"ø PIPE FLANGED OVERFLOW OUTLET (B.O.P. ELEV = 14'-0" ABOVE TANK BOTTOM).
TANKS ALSO SHALL HAVE (NOT SHOWN): MANHOLE W/ ACCESS TO MANHOLE (LOCATION AT OWNER DISCRETION).
ROOF VENT GOOSE NECK W/ FLANGE TO ALLOW FOR OPTIONAL VENT LINE ATTACHMENT.
FLUSH TYPE CLEANOUT (NOT SHOWN).

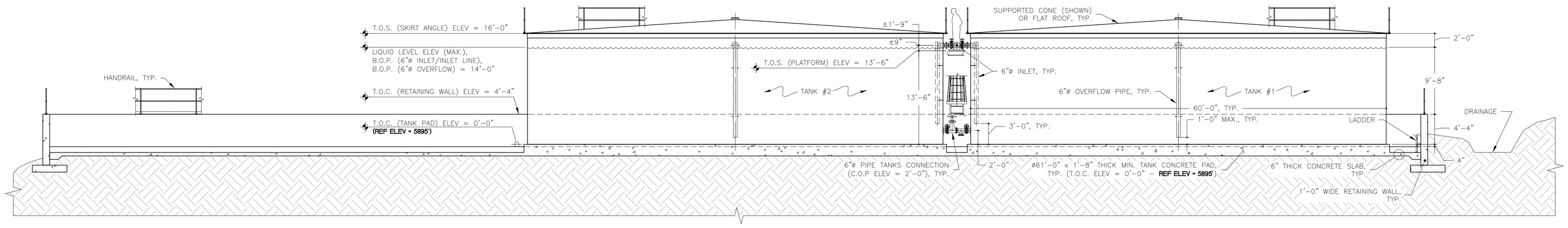
TANK MATERIAL: MILD CARBON STEEL.
REF ELEV = 0'-0' - 5895' (T.O.C. OF TANK CONCRETE PADS).

1'-6" – T.O.C. ELEV.
– SLAB SLOPE.
– GUTTER SLOPE.

(1) TOPOGRAPHY DATA FROM OVERALL MAP FOR WESTERN UTAH COPPER CO. BY PLATT AND PLATT, INC. (DATE: NOVEMBER 2008, DRAWING: NAMtopoGRID.dwg).

(2) GROUND CONTOUR ELEVATION, FEET (SEE NOTE 1).

(3) COORDINATE SIZE, ELEV AND LOCATION OF PUMP STATION CONCRETE PADS W/ PUMP STATION.
COORDINATE LOCATION OF PUMP STATION OUTLET W/ PUMP STATION.



SECTION

SCALE: 1/8" = 1'-0" LOOKING WEST B

PRELIMINARY
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11-06-2013

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QLTY. CONTROL					

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COPPER LEACH/CCD PROJECT - PHASE 1
SOLVENT EXTRACTION, ELECTROWINNING
LEACH CIRCUIT TANKS/CCD
ACID STORAGE UNIT LAYOUT

SCALE: AS NOTED

DRAWING NO. 62-GA-01

SHEET 1 OF X

REVISION P1