DOE/MC/30097 -- 5017
(DE96000556)

Energy and Environmental Research Emphasizing Low-Rank Coal Task 3.4 -- Hot-Gas Cleaning

Topical Report
(Includes Semiannual Report for January - June 1995)

Greg F. Weber
Michael L. Swanson

June 1995

Work Performed Under Contract No.: DE-FC21-93MC30097

For
U.S. Department of Energy
Office of Fossil Energy
Morgantown Energy Technology Center
Morgantown, West Virginia

By

University of North Dakota
Grand Forks, North Dakota

DISCLAIMER

DOE/MC/30097 -- 5017

ENERGY AND ENVIRONMENTAL RESEARCH
EMPHASIZING LOW-RANK COAL
TASK 3.4 -- HOT-GAS CLEANING

USDOE

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Distribution Category UC-106

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P.O. Box 880
Morgantown, West Virginia 26507-0880

By
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Energy and Environmental Research Center
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Grand Forks, North Dakota 58202-9018

June 1995

ACKNOWLEDGMENT

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TASK 3.4 HOT-GAS CLEANING

1.0 INTRODUCTION

The U.S. Department of Energy's Morgantown Energy Technology Center (DOE METC) has a hot-gas cleanup (HGC) program intended to develop and demonstrate gas stream cleanup options for use in combustion- and/or gasification-based advanced power systems. One objective of the HGC program is to support the development and demonstration of barrier filters to control particulate matter. The goal is not to simply meet current New Source Performance Standards (NSPS) with respect to particulate emissions, but also to adequately protect high-efficiency gas turbines and to control particulate emissions at sufficiently low levels to meet more stringent regulatory requirements anticipated in the future.

Many prototype high-efficiency coal-fired power systems require stringent removal of particulate ash from the high-pressure, high-temperature gas stream to prevent erosion of turbine blades or contamination of fuel cells. At present, ceramic candle filters and cross-flow filters have shown the capability to reduce particle loadings in coal-fired gas streams to acceptable levels. However, long-term thermal and chemical degradation of the filters has prevented their reliable use at the relatively high temperatures required. One of the principal degradation mechanisms is vapor-phase alkali attack of aluminosilicate materials or of the silicon in silicon carbide or silicon nitride materials. The alkali interaction usually leads to the formation of new phases that have different specific volumes or thermal expansion coefficients. The differences lead to spalling of surface reaction layers, permitting further attack of the underlying material. However, until recently, the research into the performance of ceramic materials in hot gases produced during coal firing has been limited. As yet, an adequate database that would permit material selection based on coal properties is not available, and no database is available on the rates of corrosion and strength loss of the materials. A fundamental understanding of the mechanisms of vapor-phase alkali corrosion mechanisms is being developed under a separate task (See Task 6 – High-Temperature Materials). This report summarizes the accomplishments of three subtasks completed in support of the current and future hot-gas cleanup activities at the Energy & Environmental Research Center (EERC).

2.0 OBJECTIVES

The overall objective of the EERC hot-gas cleanup task is to develop reliable methods to remove particulate matter from high-temperature, high-pressure gas streams produced from coal combustion and/or gasification. Near-term task objectives include 1) design, fabrication, and assembly of a high-temperature, high-pressure bench-scale filter vessel (Subtask 3.4.2); 2) design, fabrication, and assembly of a high-temperature, high-pressure sampling train (Subtask 3.4.3); and 3) the preliminary design of a pilot-scale high-temperature, high-pressure filter vessel and support systems (Subtask 3.4.5).

Bench-scale hot-gas filter research will be performed with the pressurized fluid-bed reactor (PFBR) or the continuous fluid-bed reactor (CFBR) and a hot-gas filter vessel. The objectives of future work with the bench-scale system will be to determine particulate and vapor-phase alkali degradation of candidate ceramic filter structures as well as filter performance relative to particulate collection efficiency, differential pressure, and filter cleanability. Construction of the high-temperature, high-pressure sampling system was intended to support bench- and pilot-scale activities with respect to conventional particulate sampling (total mass and particle-size distribution) and hazardous air pollutant (HAP) sampling. Finally, pilot-scale tests will be performed to evaluate filter performance and determine alkali corrosion of ceramic materials with a hot-gas filter vessel attached to the EERC Transport Reactor Development Unit (TRDU). Future experimental activities are expected to be funded as separate tasks within the Cooperative Agreement and other DOE METC contracts as well as private sector contracts.

3.0 ACCOMPLISHMENTS

3.1 Bench-Scale Measurements

Originally, a probe system that could be used for long-term ceramic filter testing in the pressurized drop-tube furnace (PDTF) was proposed for Subtask 3.4.2. The probe system was originally proposed because it would be a low-cost method to expose ceramic filter material to coal ash under high-temperature, high-pressure conditions over operating periods of a few hundred hours. However, because of difficulties in controlling the temperature in the zone of the furnace where the ceramic filter material would be operated and because the high workload on the PDTF makes it difficult to schedule long operating periods devoted strictly to ceramic filter material testing, EERC personnel determined that assembly of a probe system for use in the PDTF would not be appropriate. Alternative approaches were considered by EERC personnel and discussed with the DOE METC Performance Monitor in the first quarter of 1994 (January – March). Alternative approaches considered include building a bench-scale filter vessel to be used with bench-scale pressurized combustion and gasification reactor systems. A second option would involve building an extractive sampling system to pull a slipstream of gas for testing small filter elements in conjunction with the operation of any EERC combustion or gasification system.

The design and construction of a bench-scale filter vessel to be used in conjunction with the bench-scale PFBR (for combustion) and the CFBR (for gasification/pyrolysis) was selected as the best option for obtaining high-temperature, high-pressure operational data on various filter elements. Also, it was decided that the filter vessel should be designed to permit future use as a slipstream device on other larger-scale pressurized combustion and gasification systems and atmospheric combustion systems at the EERC.

The PFBR was constructed to simulate the bed chemistry, ash interactions, emissions evaluation, and hot-gas cleanup testing from a PFB under closely controlled conditions. Typical operating conditions for this reactor are shown in Table 1. This 3-in.-ID by 4-ft-high, pressurized and heated reactor and 2-in.-ID hot cyclone nominally combusts 4 lb/hr of coal. The reactor is capable of operating at 1700°F and 11 atmospheres (150 psig) pressure. The CFBR is capable of nominally gasifying 4 lb/hr of coal. The bottom section of the CFBR is made of 3-in. pipe and is 33 in. in length. The top section is made of 4-in. pipe and is 18.75 in. in length. The reactor currently has two ceramic fiber heaters to maintain vessel temperature and eliminate hot spots. The CFBR and 3-in.-ID hot cyclone are capable of operation at a maximum of 13 atmospheres (175 psig) and 1500°F. Typical CFBR operating conditions are shown in Table 2.

TABLE 1

Typical PFBR Operating Conditions

Reactor Diameter	2.875-in. ID
Temperature	1400°–1700°F
Pressure	0–150 psig
Gas Flow Rate	1–30 scfm
Coal Feed Rates	1–8 lb/hr
Velocities	1–10 ft/sec
Cyclone Exit Temp.	1600°F maximum
Particulate Loading	200–9000 ppm

TABLE 2

Typical CFBR Operating Conditions

Reactor Diameter		2.9-in. ID
Temperature		1300°–1500°F
Pressure		0–175 psig
Gas Flow Rate		1–10 scfm
Coal Feed Rates		Nominal 4 lb/hr
Velocities		1.5–2 ft/sec
Cyclone Exit Temp.		1475°F
Particulate Loading		300–4000 ppm
Typical Gas Composition	Raw Gas	w/o Fluidizing N_2
CO_2	4.68	26.56
CO	2.67	15.16
H_2	7.69	43.62
CH_4	1.01	5.74
N_2	84.79	8.23

Figure 1 is a drawing of the hot-gas cleanup bench-scale vessel to be used for the testing of ceramic candle filters on the 3-in. PFBR currently available at the EERC. This vessel was designed to handle all of the gas flow from the PFBR at its nominal design conditions. The vessel is approximately 10-in. ID and 66 in. long and was designed to handle this gas flow (approximately 25 scfm) at 1550°F and 150 psig. The tube sheet is interchangeable to handle different-sized filters. The method of holding the

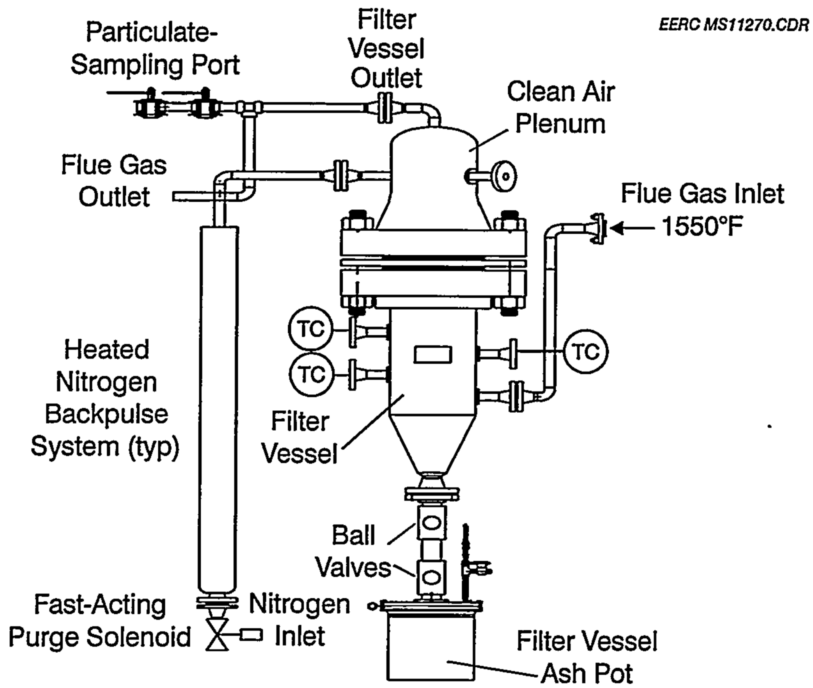


Figure 1. Schematic of high-temperature, high-pressure bench-scale hot-gas filter vessel.

candle filters in the tube sheet is expected to be filter-vendor specific. The vessel is sized such that it will handle three candle filters up to 18 in. long and up to 2.75-in. OD. This capacity will enable filter face velocities as low as 2.5 ft/min to be tested. Higher face velocities can be achieved by using shorter candles or higher gas flow rates. Proposed operating conditions for the filter vessel are shown in Table 3.

Ports were added to the filter vessel design to allow for temperature and pressure measurements to be obtained. These same ports may also be utilized to insert a water-cooled boroscope probe for visually inspecting the filter elements. The ash letdown station consists of a high-temperature valve to act as a lock hopper to isolate a pressurized ash hopper.

The nitrogen backpulse system was constructed from existing materials utilized from a previous hot-gas filter test system. The backpulse system was designed to supply a minimum of 3 candle volumes per pulse for the largest-volume candle and even higher for the smaller candle filters. The system is capable of heating the nitrogen up to 1500°F before it enters the filter vessel. The pulse duration and volume of nitrogen displaced into the vessel is controlled by the regulated pressure (up to 800 psig) of the nitrogen reservoir and the solenoid valves used to control the timing of the cold-gas pulse that displaces the hot nitrogen from the nitrogen reservoir. A heated 1-in. pipe is used to connect the 3-in. PFBR to the hot-gas filter vessel.

TABLE 3

High-Temperature, High-Pressure Bench-Scale Filter Vessel Operating Capabilities

Vessel Diameter	10-in. ID
Temperature	Up to 1550°F
Pressure	150 psig
Gas Flow Rate	Up to 30 scfm
Filter Sizes	2.375-in. OD by 18 in. long
Filter Face Velocities	2.5–15 ft/min
N_2	Backpulse system up to 1500°F inlet; both short high-pressure and long, low-pressure pulses

It is expected that this filter vessel could be used as a slipstream device on other combustion and gasification equipment at the EERC. This equipment includes pulverized coal-fired furnaces, atmospheric fluid-bed combustors (both bubbling and circulating), and gasifiers including a 100-lb/hr carbonizer and the TRDU. The bench-scale filter vessel design, component procurement, and construction have been completed. At this time, EERC personnel anticipate that the bench-scale filter vessel will begin operation in June, 1995, in support of other hot-gas cleanup tasks. Two projects planning to make use of the PFBR and the bench-scale filter vessel include an effort supporting Materials & Electrochemical Research Corporation in the completion of a Phase II SBIR activity and a multiclient filter blinding project involving DOE METC, EPRI, and several hot-gas filter vendors. Appendix A contains the detailed construction drawings for the bench-scale filter vessel.

3.2 Pilot-Scale Measurements

To complement the laboratory- and bench-scale testing of alkali attack of ceramic filter materials, future pilot-scale testing of the most inert candidate materials is anticipated using a pilot-scale filter vessel in conjunction with a pilot-scale gasification facility that has been built and operated in support of other research programs. The overall capability includes a high-temperature, high-pressure particulate sampling system.

The high-pressure, high-temperature sampling system (HPHTSS) was designed to extract dust-laden flue gas isokinetically from either an oxidizing or reducing environment. The maximum design temperature of the extracted gas stream was specified as 1800°F for the HPHTSS. The maximum working pressure of the gas stream for the HPHTSS was specified as 150 psig.

The probe for the HPHTSS is a ⅜-in.-OD and ⅛-in.-ID 304 stainless steel tube. The probe is used for only one sampling test and then discarded. The key to the sampling system is the use of a vessel, designed to withstand high-pressure and high-temperature conditions, to enclose the low-pressure sampling devices. An illustration of the HPHTSS is presented in Figure 2.

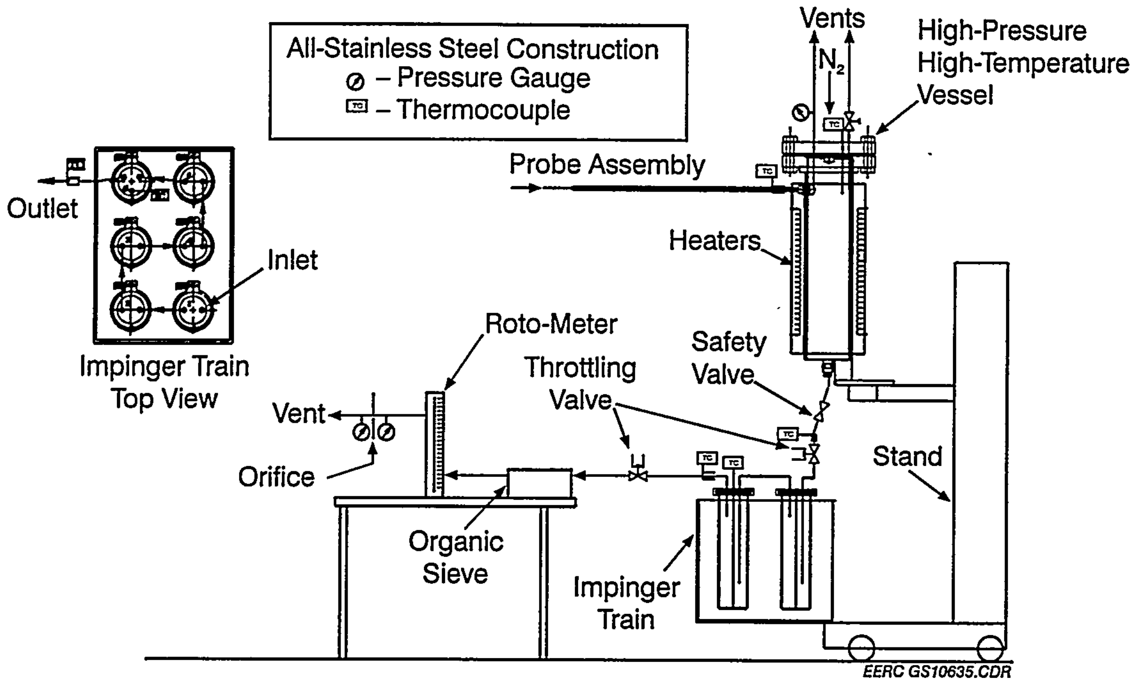


Figure 2. High-pressure, high-temperature sampling system.

The vessel was constructed of 5-in. Schedule 80 pipe and fitted with raised-face 300-lb flanges. The material used for the HPHTSS pressure vessel was 316L stainless steel. The HPHTSS was designed to house both a multicyclone assembly with backup filter as well as a backup filter alone.

The principle of operation is to pressurize the outside of the sampling device (i.e., multicyclone assembly or backup filter) with a slightly higher gas pressure than the system pressure of the flue gas. Bottled nitrogen gas will be used to pressurize the vessel. The pressure differential between the nitrogen gas within the pressure vessel and the flue gas within the sampling device will be maintained at 5 psig.

If the HPHTSS is operating in a reducing environment where the presence of organic vapors is a possibility the pressure vessel is capable of operating at temperatures as high as 1000°F and maintaining nitrogen gas pressures up to 150 psig. Electric resistance heaters of sufficient wattage will be used to heat the pressure vessel to specified temperatures.

Once the process gas exits the sampling assembly, the gas pressure is reduced through a throttling valve to approximately 50 psig. The throttling valve will also act as the flow control valve for the sampling system. A second valve (safety valve) was installed in series in the event that the primary throttling valve failed to close.

After the throttling valve, the process gas is cooled through a set of impingers to remove moisture and organic vapors if present. A set of up to six impingers may be used in this sampling system. These impingers are rated for 200 psig at 250°F maximum operating conditions. The impingers are made of 304 stainless steel with Teflon-coated interior surfaces. The Teflon-coated surfaces allow the HPHTSS to be used for trace metal sampling.

The dry gas is then throttled to atmospheric pressure and metered through a rotameter and orifice in order to measure total flow. The process gas then reenters the main gas stream for cleanup and disposal.

One complete HPHTSS sampling system has been assembled and is ready for use in support of pilot-scale gasification or combustion system operation. Plans to complete the assembly of a second sampling system were deleted from this subtask because of limitations on available funding. However, construction of a second HPHTSS pressure vessel and a second set of 304 stainless steel impingers was completed. If a second HPHTSS is found to be necessary, funding for completing its assemply will have to come from projects planning to make use of the equipment. At this time, EERC personnel anticipate that the HPHTSS will be used in support of hot-gas cleanup filter tests making use of the TRDU and the pilot-scale filter vessel and planned for the last six months of 1995 and 1996. Appendix B contains the detailed construction drawings for the HPHTSS.

Reassembly of the hot-gas test loop was deleted from this subtask because of funding limitations and delays associated with the decision process concerning the future of the TRDU. Modification and reassembly of the hot-gas test loop were factored into Subtask 3.13 – Hot-Gas Filter Testing. Subtask 3.13 was proposed to DOE METC in December 1994, was initiated in January, 1995, and involves TRDU upgrades and final design, installation, and operation of a pilot-scale filter vessel to be used with the TRDU.

3.3 Pilot-Scale, Hot-Gas Filter Design

A new activity was added in September 1993 to Task 3.4, Subtask 3.4.5 – Hot-Gas Filter Design. The purpose of the new activity was to initiate an effort to design and construct a hot-gas filter vessel to be operated in conjunction with the TRDU. The TRDU is a 200–300-lb/hr pressurized circulating fluid-bed gasifier. The TRDU has an exit gas temperature of 1800°F, a gas flow rate of 300 scfm, and an operating pressure of 120–150 psig. Work was initiated on this subtask during the first quarter of 1994. Efforts were directed at locating an existing pressure vessel that could be incorporated into a hot-gas filter system with minimal modification. Several vessels were located, and the design of each was reviewed. The preliminary filter design criteria are summarized in Table 4.

The first vessel was designed by the Allison Gas Turbine Division of General Motors Corporation. It was originally constructed for use as a hot barrier filter vessel to be used in Allison's direct coal-fired gas turbine project. Ownership of the vessel still remains with DOE, so costs associated with this vessel would only entail transportation to the EERC and modification of the vessel to meet our requirements.

The Allison filter vessel was designed and fabricated by Allison under DOE contract No. DE-AC21-86MC23165. It was designed to clean a gas stream containing <10-micron particles of frozen slag and ash. The filters and backpulse system were to be supplied by Industrial Filter and Pump Mfg. Co., Inc. A water-cooled filter tube sheet was fabricated but never installed. The vessel itself is composed of 58.5 in. of 42-in.-diameter carbon steel pipe. Both ends

TABLE 4

Design Criteria for the Pilot-Scale Hot-Gas Filter Vessel

Range of Operating Conditions	
Inlet Gas Temperature	1000°–1800°F
Operating Pressure	120–150 psig
Volumetric Gas Flow	300 scfm
Number of Candles	Up to 31
Candle Spacing	4 in. ℄ to ℄
Filter Face Velocity	2–10 ft/min
Particulate Loading	$<$10,000 ppm
Temperature Drop Across Hot-Gas Filter Vessel	$<$50°F
Nitrogen Backpulse System	Unheated

of the pipe are capped with 48-in. torispherical heads. A number of nozzles penetrate the wall of the vessel. All flanged surfaces have been converted from raised-face, spiral-wound gasket designs to metal/metal seat applications. The head on the clean side of the filter tube sheet has 26 nozzle penetrations to accommodate the filter backpulse system, as well as the clean gas outlet nozzle. The vessel was used in a pass-through mode, without the tube sheet installed, in a test that exposed it to 1500°F reducing gas at 200 psig. The design limits were 2000°F and 300 psig.

A visit was made to Allison in the first quarter of 1994 to inspect the vessel. It had been stored in an unprotected outside storage site. All carbon steel surfaces were slightly rusted, including the flange sealing surfaces. The refractory liner was cracked but had very little loss of material from spalling. It appeared that a number of the flanges would need to be resurfaced or replaced to return them to compatibility with the raised-face design commonly used at the EERC. The refractory would probably have to be removed and replaced to allow for modification of nozzles in the shell.

The second vessel selected for consideration was the C-121 vessel used on the KRW Gasifier. The vessel is of similar construction to that of the Allison vessel. The vessel holds an American Society of Mechanical Engineers (ASME) stamp for 650°F shell temperature at 300 psig. The shell is a 48-in.-diameter pipe 8 ft 6 in. in length. The ends are torispherical heads. A number of nozzle penetrations exist in the head and shell in addition to the main gas inlet and outlet. This vessel, as well as the majority of equipment from the KRW Waltz Mill site, is now owned by Stanton Energy Industry Consultants, Inc. (SEIC). The vessel appeared to be suited to the application; however, in early 1994, SEIC was not interested in selling the vessel and associated subsystems, preferring to enter into a lease arrangement that was not attractive to the EERC.

A third vessel was discovered in the equipment storage area at the EERC. It was acquired several years ago as surplus equipment from the National Aeronautic Space Administration (NASA) Lewis Research facility. It was designed as a hot-gas filter vessel for use on a PFBC. It holds an ASME stamp for a 400°F shell temperature at 135 psig; however, it has been determined that this vessel is overdesigned for its previous task and meets ASME code for 160 psig with a metal temperature of 600°F. It was designed by Aerodyne Development Corporation. The shell is fabricated from 36-in.-diameter carbon steel pipe. It has a torispherical head on the clean side of the filter tube sheet. The lower head of the shell is a cone that reduces to an 8-in. flanged ash discharge nozzle.

This vessel had been in an outdoor storage yard unused for a number of years. To assess its potential for the application, a certification report was obtained from the National Board. The vessel was brought into the shop and briefly inspected. The mineral wool insulation and stainless steel inner liner were removed from the interior of the vessel to allow inspection of the inner surface of the vessel. Minimal corrosion was found.

Heat-transfer calculations were performed on the vessel to determine the usable bore diameter that would remain in the vessel after sufficient refractory had been installed to keep the vessel skin temperatures below the 600°F rated maximum. It was determined that a 24-in. ID could be maintained using 1600°F inlet gas temperatures and mass flow rates matching the output of the TRDU. This would allow for installation of up to 19 candle filter elements. However, the desire for a gas shroud in the filter vessel design made it marginal to get the desired number of candles inside the shroud while maintaining the temperature drop across the vessel to <50°F.

The preliminary heat-transfer calculations also pointed out the need to modify one or more of the nozzles on the vessel. The dirty gas inlet nozzle must be increased in diameter to allow for a thicker layer of refractory if <600°F metal temperatures are to be maintained in the area of the nozzle. Additionally, a preheat natural gas burner will be required to prevent condensation from collecting in the vessel while the gasifier is starting up. The hot gas from the burner will enter the vessel via the same inlet as the dirty gas. Another requirement identified was the installation of a shroud inside the filter vessel to direct the inlet gas stream to the top of the vessel and facilitate a downward gas flow over the filters to minimize ash reentrainment as a result of on-line cleaning.

Based on an initial favorable review of the NASA Lewis vessel, a preliminary filter vessel design was completed to identify required modifications and estimate material and labor costs to complete the final design, vessel modifications, and installation requirements. As a result of the preliminary design effort, it was determined that a number of significant modifications to the NASA Lewis vessel would be required. These included adding additional nozzles to the vessel wall, relocating and increasing the size of the gas inlet nozzle, adding nozzles to the vessel head to accommodate the backpulse system, and extending the overall length of the vessel. A drawing of the modified vessel design is presented in Figure 3. Based on this design, material and labor estimates were obtained for the modifications from a local fabricator. The final estimated cost to complete the required modifications was $11,800, significantly higher than originally anticipated.

Because of the high modification cost estimate, it was suggested that it may be prudent to estimate the cost of constructing a new vessel. As a result, EERC personnel prepared a bid package to be issued to vendors for the construction of a new vessel. The design specifications were for a metal temperature of 800°F and operating pressures of up to 150 psi. A drawing of the new vessel design is presented in Figure 4. The only significant differences in the new vessel design versus the original modified vessel design was an increase in diameter from 36 to 48 in. and an increase in the surface temperature limit design. A larger diameter and higher surface temperature design limit were chosen to permit greater vessel flexibility and eliminate design constraints relative to refractory selection and wall thickness, shroud design and installation, and

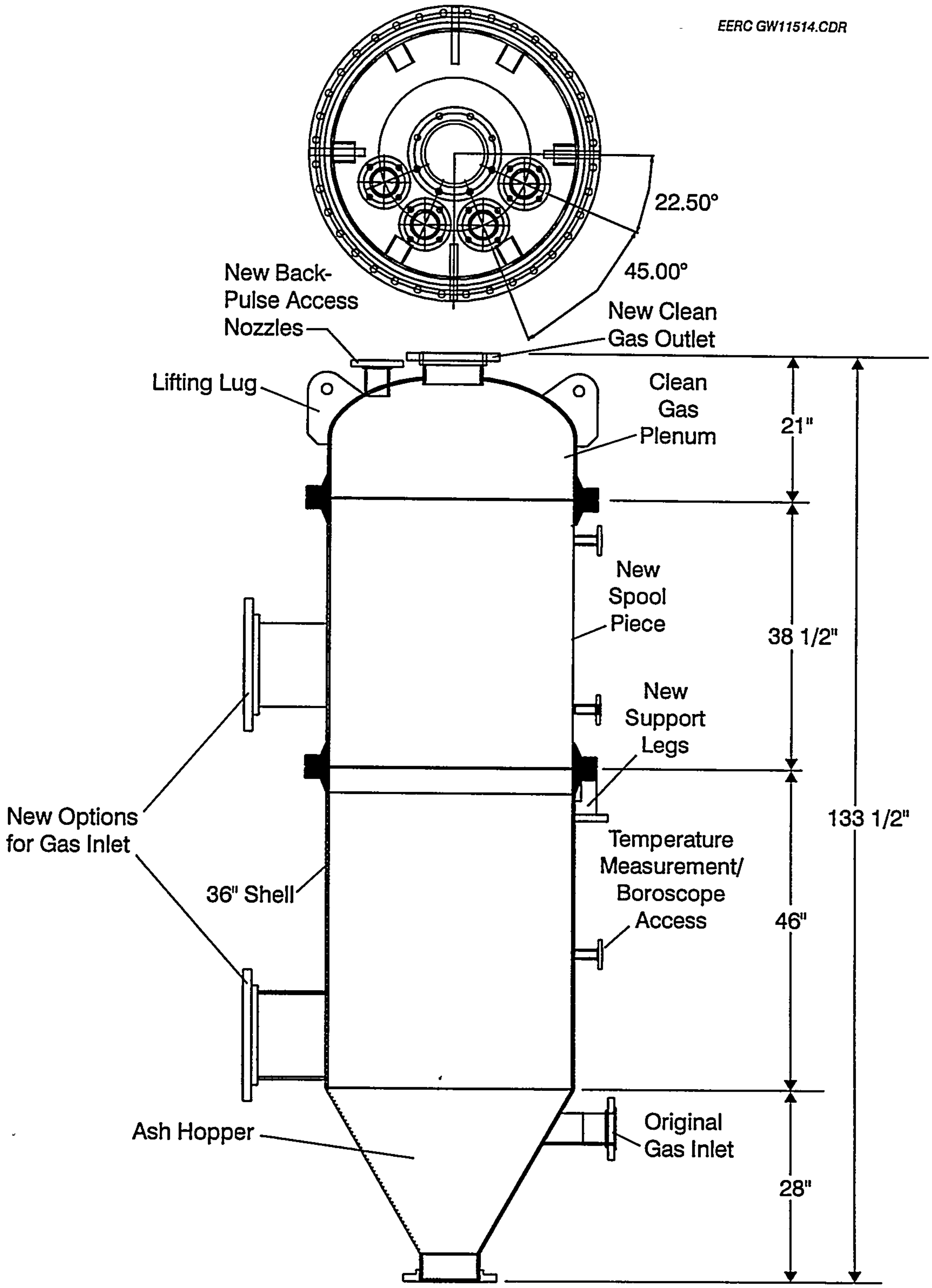


Figure 3. Schematic of NASA Lewis filter vessel design modifications.

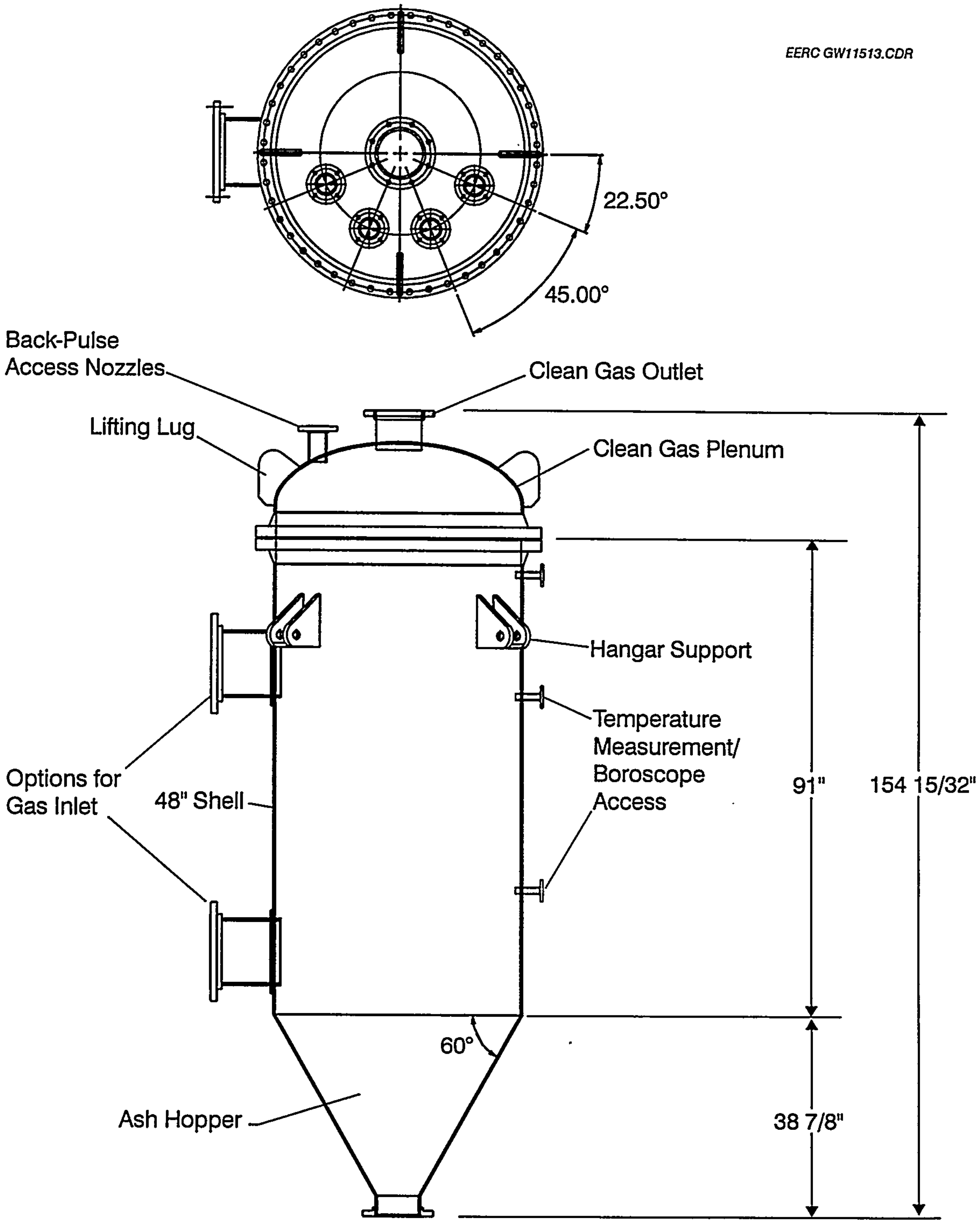


Figure 4. Schematic of the new filter vessel design.

filter diameter and spacing. Responses to the bid package were received from six out of nine potential fabricators with cost estimates ranging from $14,700 to $33,200. Based on the bid packages received, the EERC determined that manufacturing a new, slightly larger, filter vessel was a more prudent approach than modifying the NASA Lewis vessel. Therefore, a purchase order was issued to Arrow Tank & Engineering Co. (Cambridge, MN) to construct the new filter vessel at a cost of $14,700. The anticipated delivery date for the new vessel is late-June 1995.

Funding for Subtask 3.4.5 was adequate to complete the preliminary filter vessel design activities, prepare a bid package for the new vessel, and purchase the new vessel. Installation of the new vessel along with piping requirements will be accomplished as part of the scope of work outlined in Subtask 3.13 - Hot-Gas Filter Testing. This new subtask has also supported upgrades to the TRDU and is anticipated to support as many as three 200-hour filter tests in the next 21 months. First-year funding was made available in March 1995 and has supported upgrades to the TRDU, will support installation of the new filter vessel and piping requirements, and will support one 200-hour filter test if initial shakedown of the TRDU demonstrates acceptable performance after the upgrades have been completed. Figure 5 depicts the preliminary filter vessel location in the gasifier tower and piping requirements for its future use in conjunction with the TRDU.

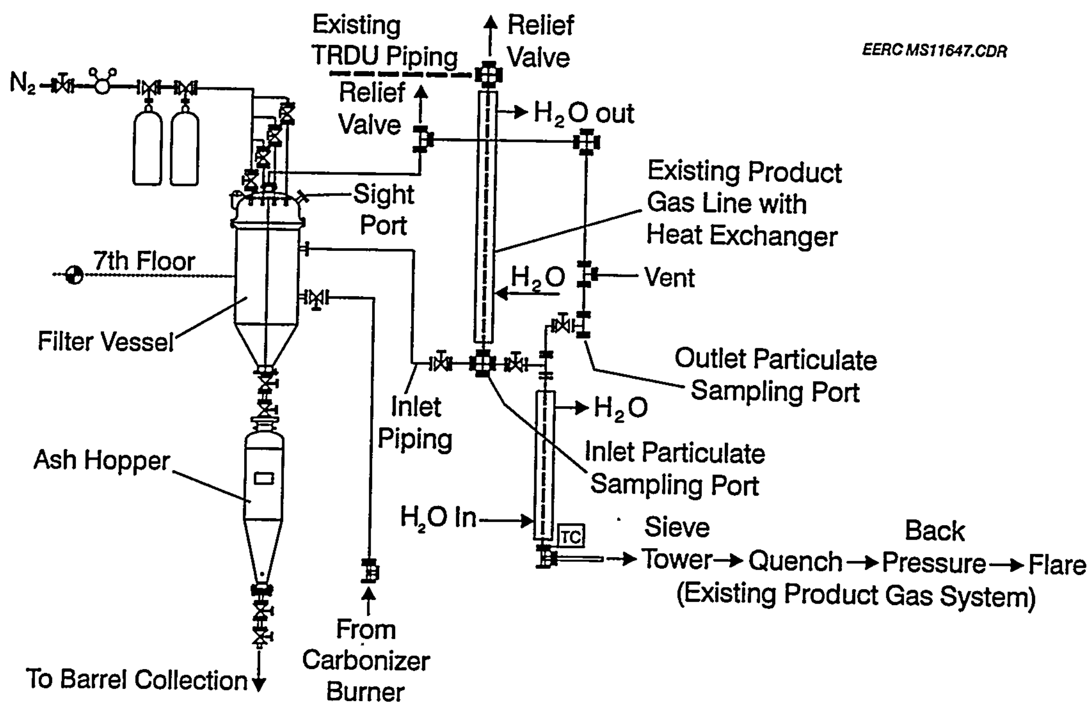
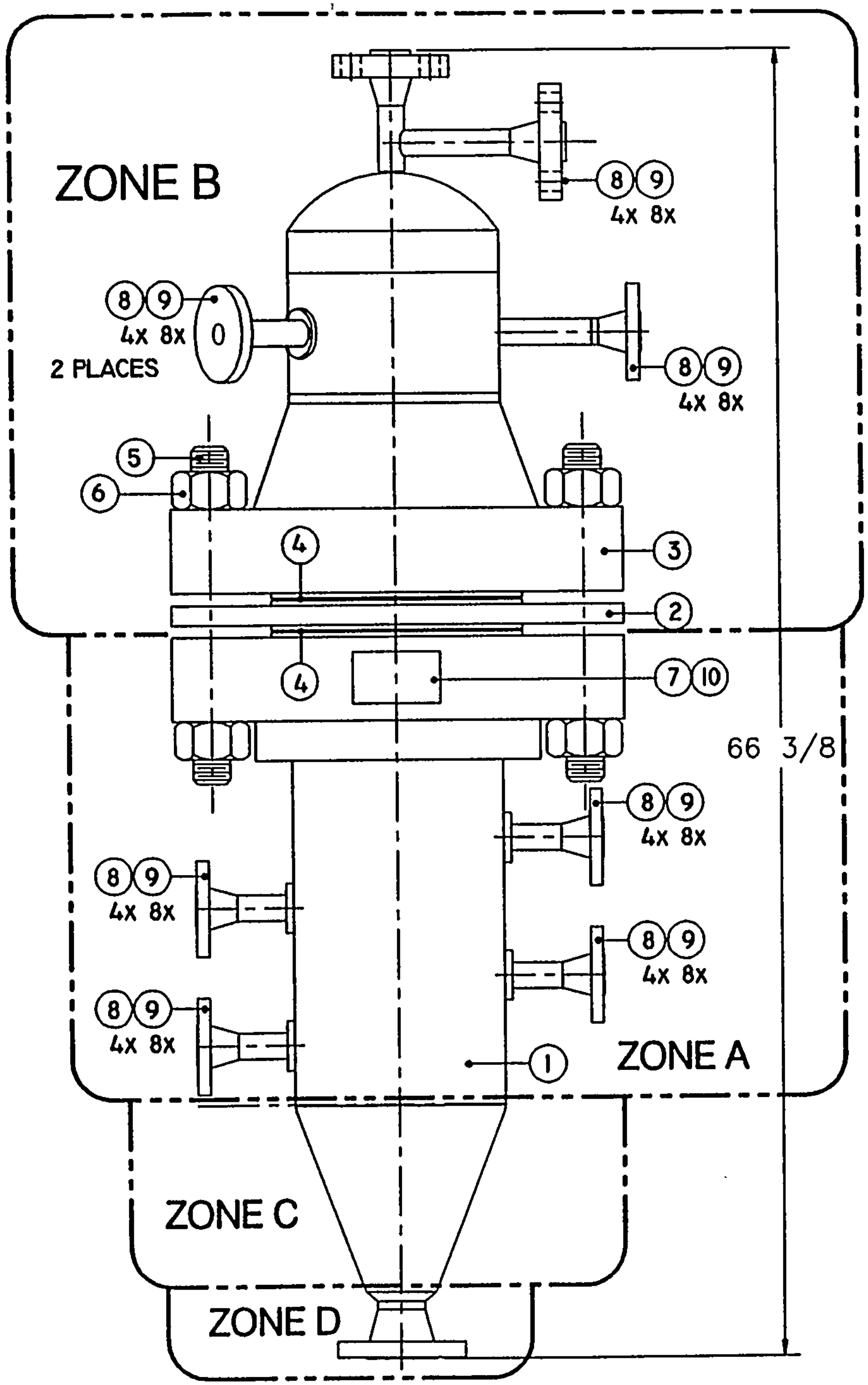


Figure 5. Schematic showing additional high-temperature, high-pressure piping needed for high-temperature (1000°–1200°F) filter testing.

APPENDIX A

DETAILED CONSTRUCTION DRAWINGS OF BENCH-SCALE, HOT-GAS FILTER VESSEL



GENERAL NOTES:

1. FOR ALL BOLT TORQUE VALUES REFER TO DRAWING 1647

DESIGN PARAMETERS

DESIGN ZONE	PRESSURE		DESIGN TEMP MAX	DESIGN TEMP MIN	CORROSION ALLOWANCE	OPERATING FLUID
A	160	MAWP PSI	1800	-30	0.03 INCHES	FLUE GAS
	150	MOP PSI	1800	-20		
B	160	MAWP PSI	1550	-30	0.03 INCHES	FLUE GAS
	150	MOP PSI	1550	-30		
C	160	MAWP PSI	1500	-20	0.03 INCHES	FLUE GAS
	150	MOP PSI	1800	-20		
D	160	MAWP PSI	1250	-20	0.03 INCHES	FLUE GAS
	150	MOP PSI	1250	-30		

DESIGN [A] LIMITED BY: 10" PIPE
DESIGN [B] LIMITED BY: 10" PIPE
DESIGN [C] LIMITED BY: 10" x 2" CONE
DESIGN [D] LIMITED BY: 2" FLANGE
DESIGN RATING BASED ON ASME B31.3.

PRESSURE TEST

TEST ZONE	TEST PRESSURE	TEST TEMPERATURE	TEST FLUID
A	1560 PSI MAX	75 °F	D.I.H_2O
B	1560 PSI MAX	75 °F	D.I.H_2O
C	1560 PSI MAX	75 °F	D.I.H_2O
D	1560 PSI MAX	75 °F	D.I.H_2O

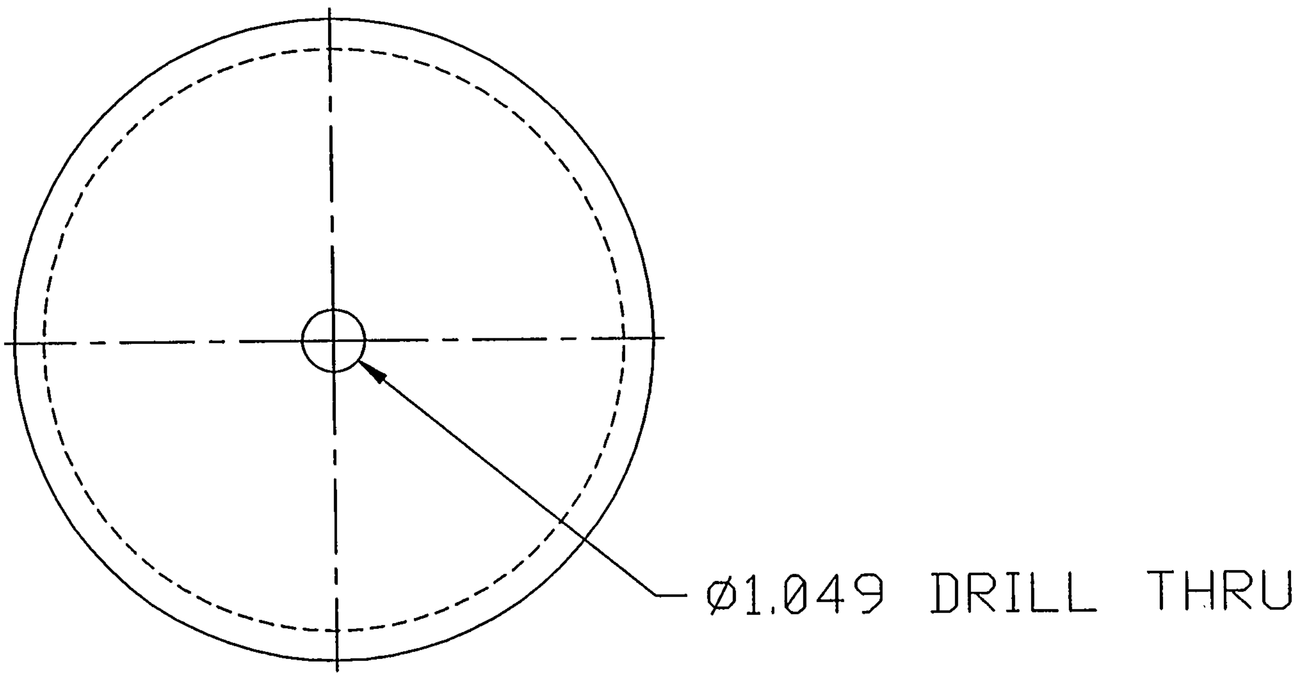
DESIGN [A] LIMITED BY: 10" PIPE
DESIGN [B] LIMITED BY: 10" PIPE
DESIGN [C] LIMITED BY: 10" x 2" CONE
DESIGN [D] LIMITED BY: 2" FLANGE
DESIGN RATING BASED ON ASME B31.3.

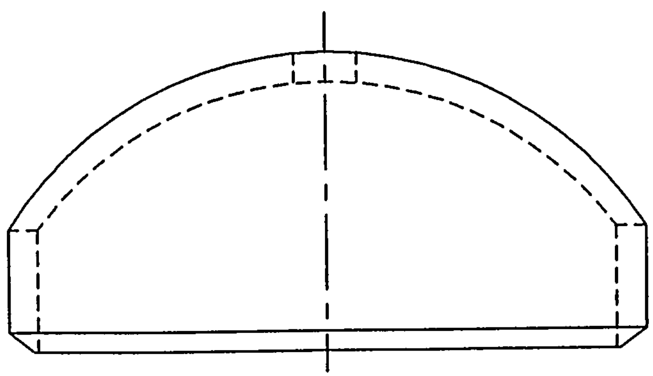
-2 QTY	-1 QTY	ITEM	PART NO	DESCRIPTION	MATERIAL SPEC	Q.C.	DATE
-	4	10		POP RIVETS	SS		
-	64	9		NUT, HEAVY HEX, 7/8-9UNC-2A	A 194 GR.8 HA		
-	32	8		STUD BOLT, 7/8-9UNC-2B x 5	A 193 B8 M CL.1		
-	1	7	1942-4	PLATE, VESSEL IDENTIFICATION			
-	64	6		NUT, HEAVY HEX 1 7/8--6UNC-2A	A 194 GR.8 HA		
-	32	5		STUD BOLT, 1 7/8-6UNC-2B x 14.25	A 193 B8 M CL.1		
-	2	4	CG-15R	GASKET, 18" (FLEXITALLIC)	SS		
-	1	3	1982	VELDMENT, TOP			
-	1	2	1981	FILTER HOLDER			
-	1	1	1984	VELDMENT, BOTTOM			

FILTER VESSEL ASSEMBLY, 3" PFBC

DRAWN BY: UHRICH	ESS CHK:	DATE:	W:228 E:185
UNLESS SPECIFIED ALL DIMENSIONS IN INCHES	ENGR:	DATE:	FUND NO: 4261
TOLERANCES:	CLIENT:	DATE:	REV: - SCALE: 1:1
FRACTIONAL ± 1/16	MGR:	DATE:	SHEET 1 OF 1
3 PLC. DEC. ± 0005 / 2 PLC. DEC. ± 0030 / 1 PLC. DEC. ± 01	APVD:	DATE:	PRESSURE TEST DRAWING LEVEL: 1977
ANGULAR ± 2-1/2 DEGREES	FINAL ASSY: 122	NEXT ASSY: -	DWG. NO: 1977

1001-1J



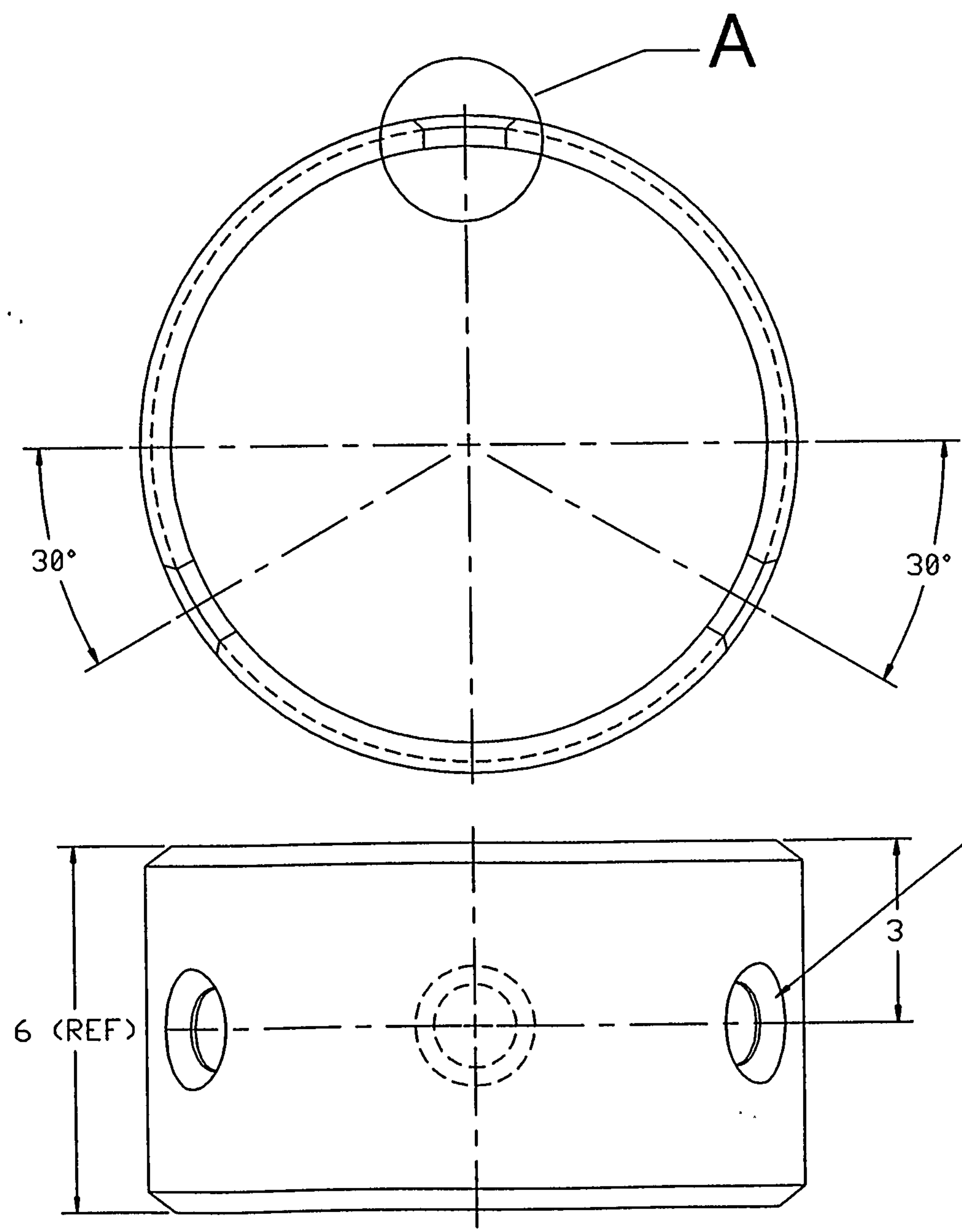


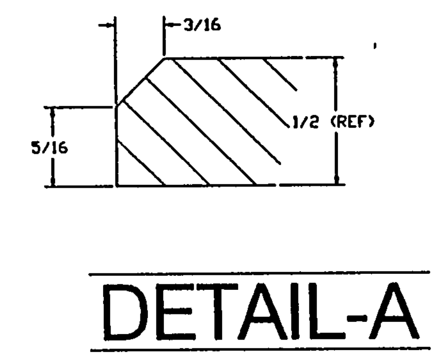
-2 QTY	-1 QTY	ITEM	PART NO	DESCRIPTION	MATERIAL SPEC	Q.C.	DATE
-	1	1		CAP, PIPE, 10", EXTRA STRONG	HAYNES ALLOY 556		

PIPE CAP, MODIFIED, FILTER VESSEL, 3" PFBC

DRAWN BY: UHRICH	ESS CHK:	DATE:	W: 228 E: 185
UNLESS SPECIFIED ALL DIMENSIONS IN INCHES	ENGR:	DATE:	FUND NO: 4261
TOLERANCES:	CLIENT:	DATE:	REV: - SCALE: 1:1
FRACTIONAL ± 1/16 3 PLC. DEC. ± .005 2 PLC. DEC. ± .030 1 PLC. DEC. ± .1 ANGULAR ± 2-1/2 DEGREES	MGR:	DATE:	SHEET 1 OF 1
	APVD:	DATE:	PRESSURE TEST DRAWING LEVEL: 1977
	FINAL ASSY: 122	NEXT ASSY: 1986	DWG. NO: 1978

1001-1J





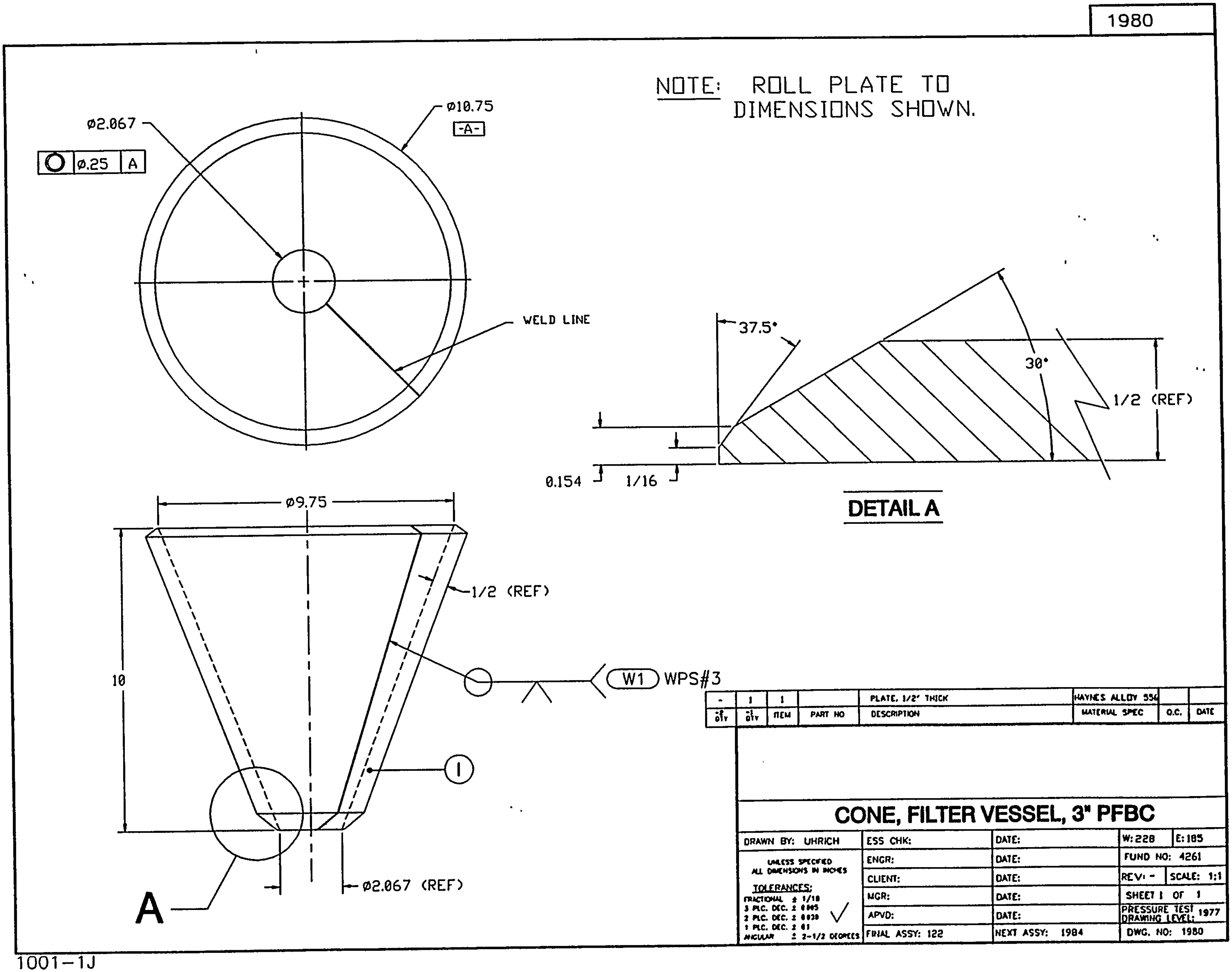
DETAIL-A

-	1	1		PIPE, 10"-SCH.80 x 6"	HAYNES ALLOY 556		
QTY	QTY	ITEM	PART NO	DESCRIPTION	MATERIAL SPEC	O.C.	DATE

PIPE, MODIFIED, TOP SECTION, FILTER VESSEL, 3" PFBC

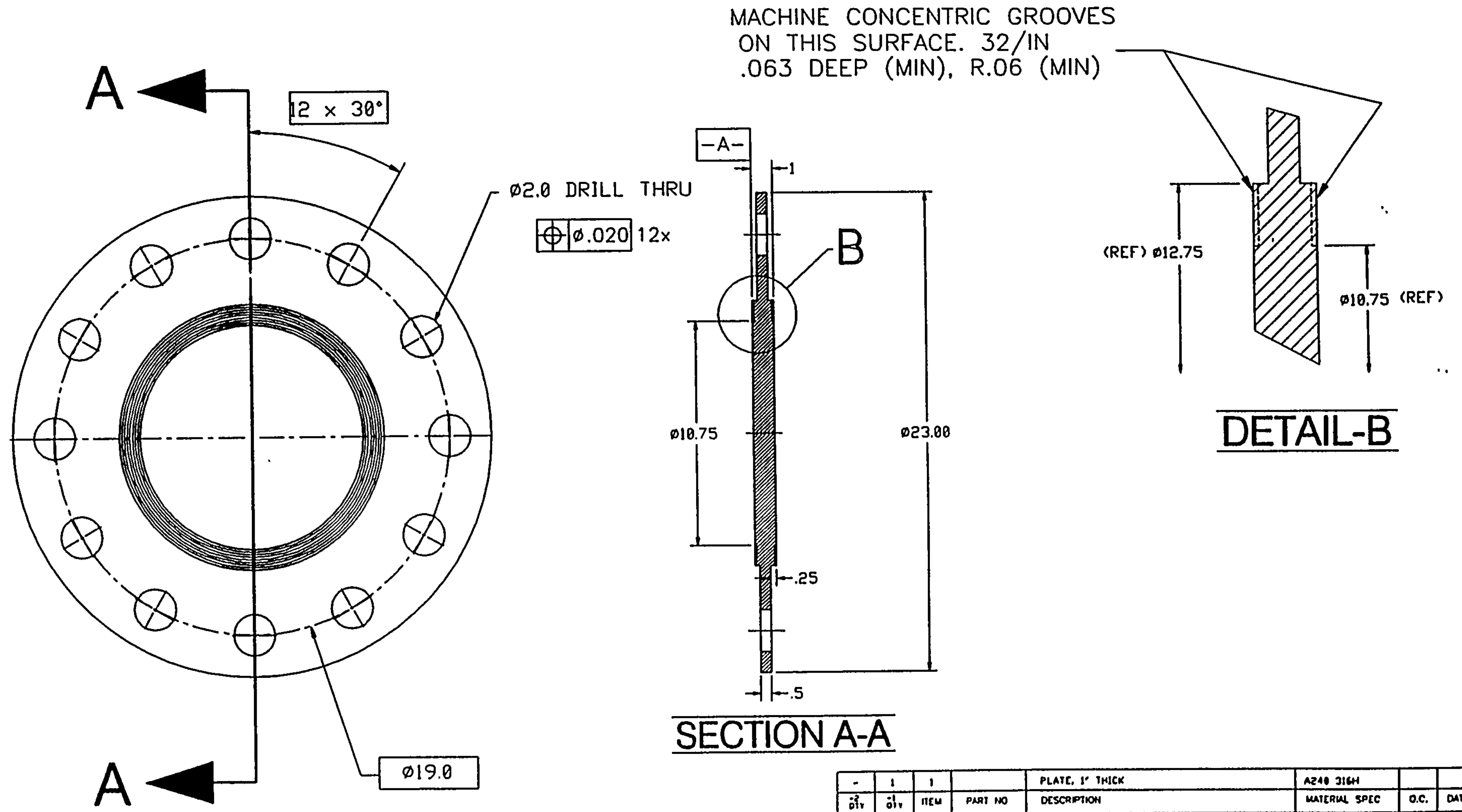
DRAWN BY: UHRICH	ESS CHK:	DATE:	W: 228	E: 185
UNLESS SPECIFIED ALL DIMENSIONS IN INCHES	ENGR:	DATE:	FUND NO: 4261	
TOLERANCES:	CLIENT:	DATE:	REV: -	SCALE: 1:1
FRACTIONAL ± 1/16 3 PLC. DEC. ± .005 2 PLC. DEC. ± .030 1 PLC. DEC. ± .01 ANGULAR ± 2-1/2 DEGREES	MGR:	DATE:	SHEET 1 OF 1	
	APVD:	DATE:	PRESSURE TEST DRAWING LEVEL: 1977	
	FINAL ASSY: 122	NEXT ASSY: 1985	DWG. NO: 1979	

1001-1J



1980
NOTE: ROLL PLATE TO DIMENSIONS SHOWN.
Ø2.067
Ø10.75
-A-
Ø.25 A
WELD LINE
37.5°
30°
1/2 (REF)
0.154
1/16
DETAIL A
Ø9.75
1/2 (REF)
10
W1 WPS#3
1
A
Ø2.067 (REF)
- | 1 | 1 | | PLATE, 1/2" THICK | HAYNES ALLOY 556
QTY | QTY | ITEM | PART NO | DESCRIPTION | MATERIAL SPEC | Q.C. | DATE
CONE, FILTER VESSEL, 3" PFBC
DRAWN BY: UHRICH
ESS CHK: DATE:
ENGR: DATE:
CLIENT: DATE:
MGR: DATE:
APVD: DATE:
FINAL ASSY: 122
NEXT ASSY: 1984
UNLESS SPECIFIED ALL DIMENSIONS IN INCHES
TOLERANCES:
FRACTIONAL ± 1/16
ANGULAR ± 2-1/2 DEGREES
W: 228 E: 185
FUND NO: 4261
REV: - SCALE: 1:1
SHEET 1 OF 1
PRESSURE TEST DRAWING LEVEL: 1977
DWG. NO: 1980
1001-1J

1981

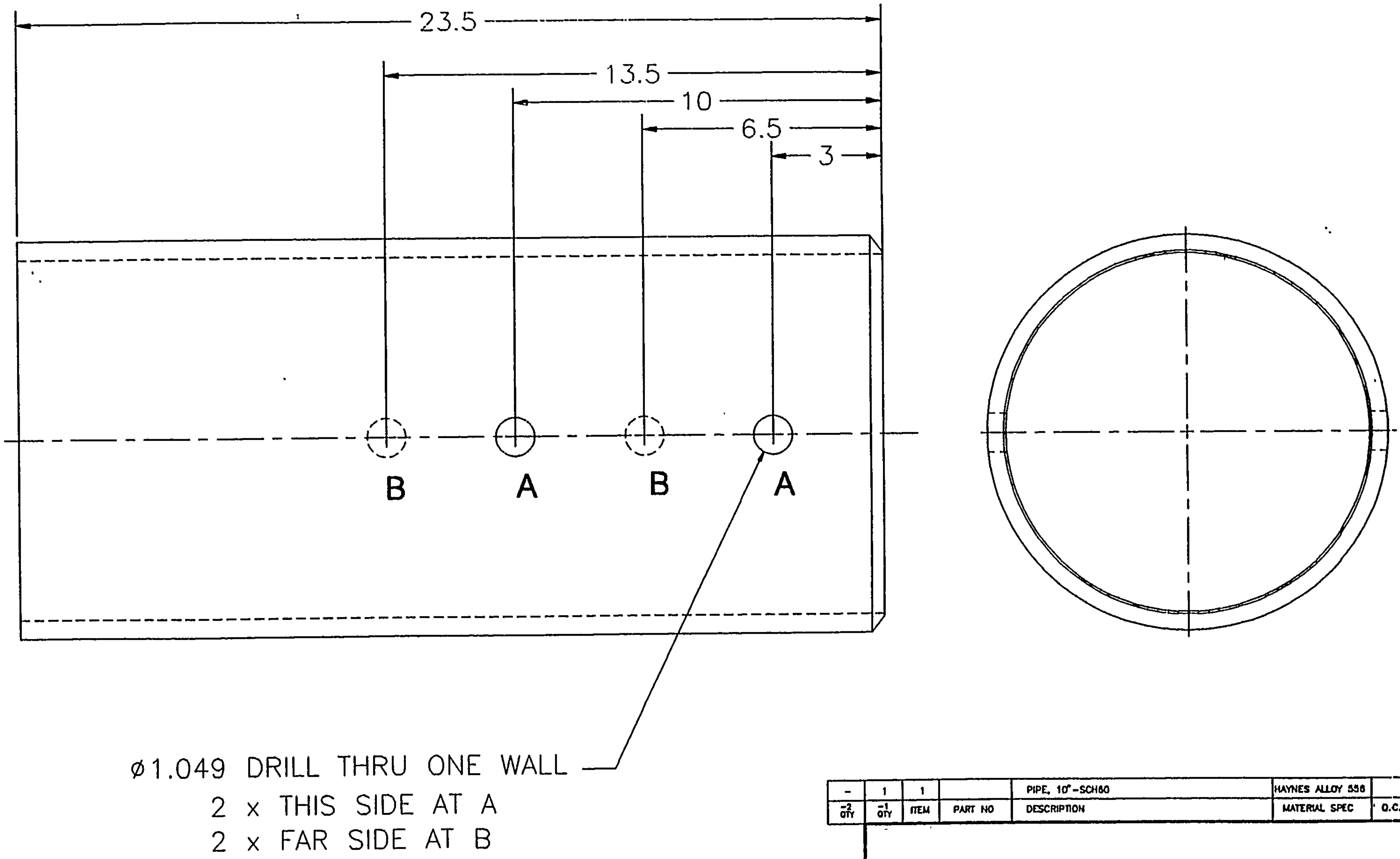


-	1	1		PLATE, 1" THICK	A240 316H		
-2 QTY	-1 QTY	ITEM	PART NO	DESCRIPTION	MATERIAL SPEC	Q.C.	DATE

TUBE SHEET, FILTER VESSEL, 3" PFBC

DRAWN BY: UHRICH	ESS CHK:	DATE:	W:228 E:185
UNLESS SPECIFIED ALL DIMENSIONS IN INCHES	ENGR:	DATE:	FUND NO: 4261
TOLERANCES:	CLIENT:	DATE:	REV: - SCALE: NTS
FRACTIONAL ± 1/16 3 PLC. DEC. ± .005 2 PLC. DEC. ± .030 1 PLC. DEC. ± .1 ANGULAR ± 2-1/2 DEGREES	MGR:	DATE:	SHEET 1 OF 1
	APVD:	DATE:	PRESSURE TEST DRAWING LEVEL: 1977
	FINAL ASSY: 122	NEXT ASSY: 1977	DWG. NO: 1981

1001-1J



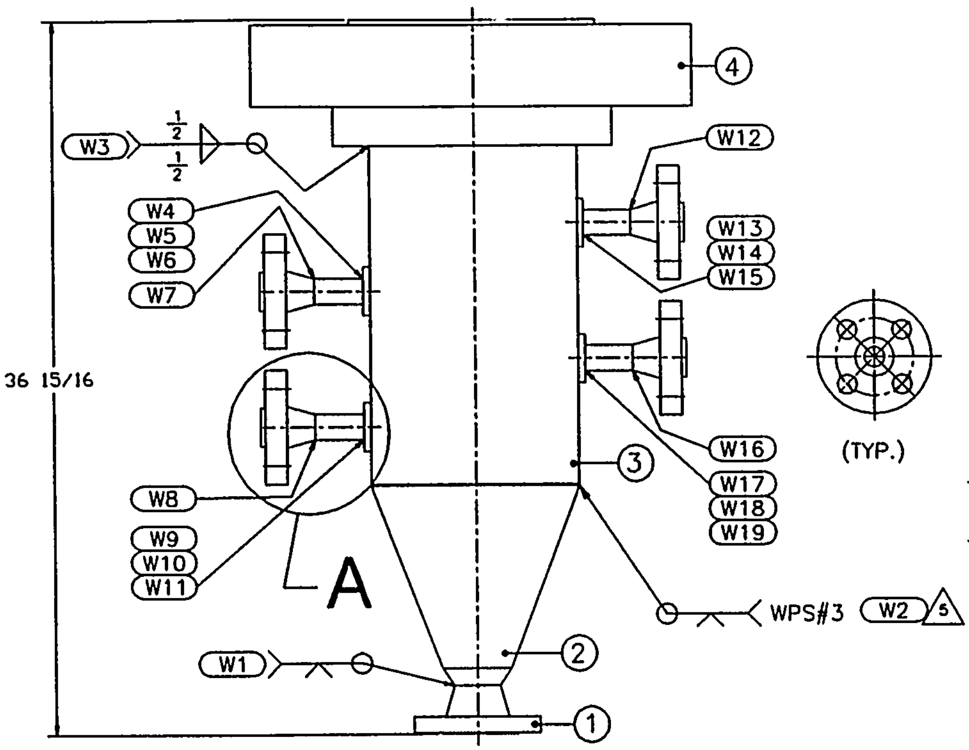
-	1	1		PIPE, 10"-SCH60	HAYNES ALLOY 556		
-2 QTY	-1 QTY	ITEM	PART NO	DESCRIPTION	MATERIAL SPEC	Q.C.	DATE

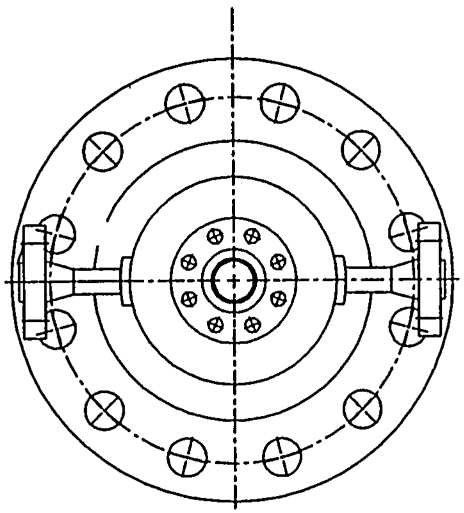
PIPE, MODIFIED, BOTTOM SECTION, FILTER VESSEL, 3" PFBC

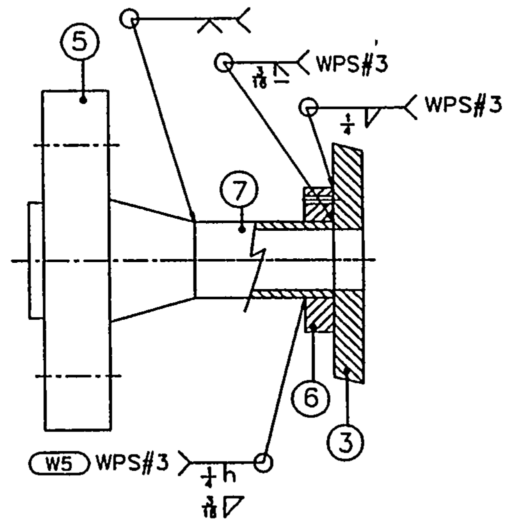
DRAWN BY: UHRICH	ESS CHK:	DATE:	W: 228	E: 185
UNLESS SPECIFIED ALL DIMENSIONS IN INCHES	ENGR:	DATE:	FUND NO: 4261	
TOLERANCES:	CLIENT:	DATE:	REV: –	SCALE: 1:1
FRACTIONAL ± 1/16 3 PLC. DEC. ± 0.005	MGR:	DATE:	SHEET 1 OF 1	
2 PLC. DEC. ± 0.030 ✓	APVD:	DATE:	PRESSURE TEST DRAWING LEVEL: 1977	
1 PLC. DEC. ± 0.1 ANGULAR ± 2-1/2 DEGREES	FINAL ASSY: 122	NEXT ASSY: 1984	DWG. NO: 1983	

GENERAL NOTES:

1. USE WPS NO. 8 UNLESS OTHERWISE NOTED.
2. CERTIFIED WELDING IS REQUIRED AS PER ASME B31.3 EXCEPT AS NOTED.
3. INSPECT ALL LONGITUDINAL WELDS.
4. INSPECT 5 % MIN OF CIRCUMFERENTIAL WELDS.







DETAIL-A
(TYP.)

		8					
	4	7		PIPE, 1"-SCH.40 x 2-3/4"	HAYNES ALLOY 556		
	4	6	1987	REINFORCEMENT PAD			
	4	5		FLANGE, 1"-1500#, RF, WN	A182 F316H		
	1	4		FLANGE, 10"-1500#, RF, SO	A182 F316H		
	1	3	1983	PIPE, MODIFIED, BOTTOM SECTION, FILTER VESSEL, 3" PFBC			
	1	2	1980	CONE, FILTER VESSEL, 3" PFBC			
	1	1		FLANGE, 2"-300#, RF, WN	A182 F316H		
-2 QTY	-1 QTY	ITEM	PART NO	DESCRIPTION	MATERIAL SPEC	O.C.	DATE

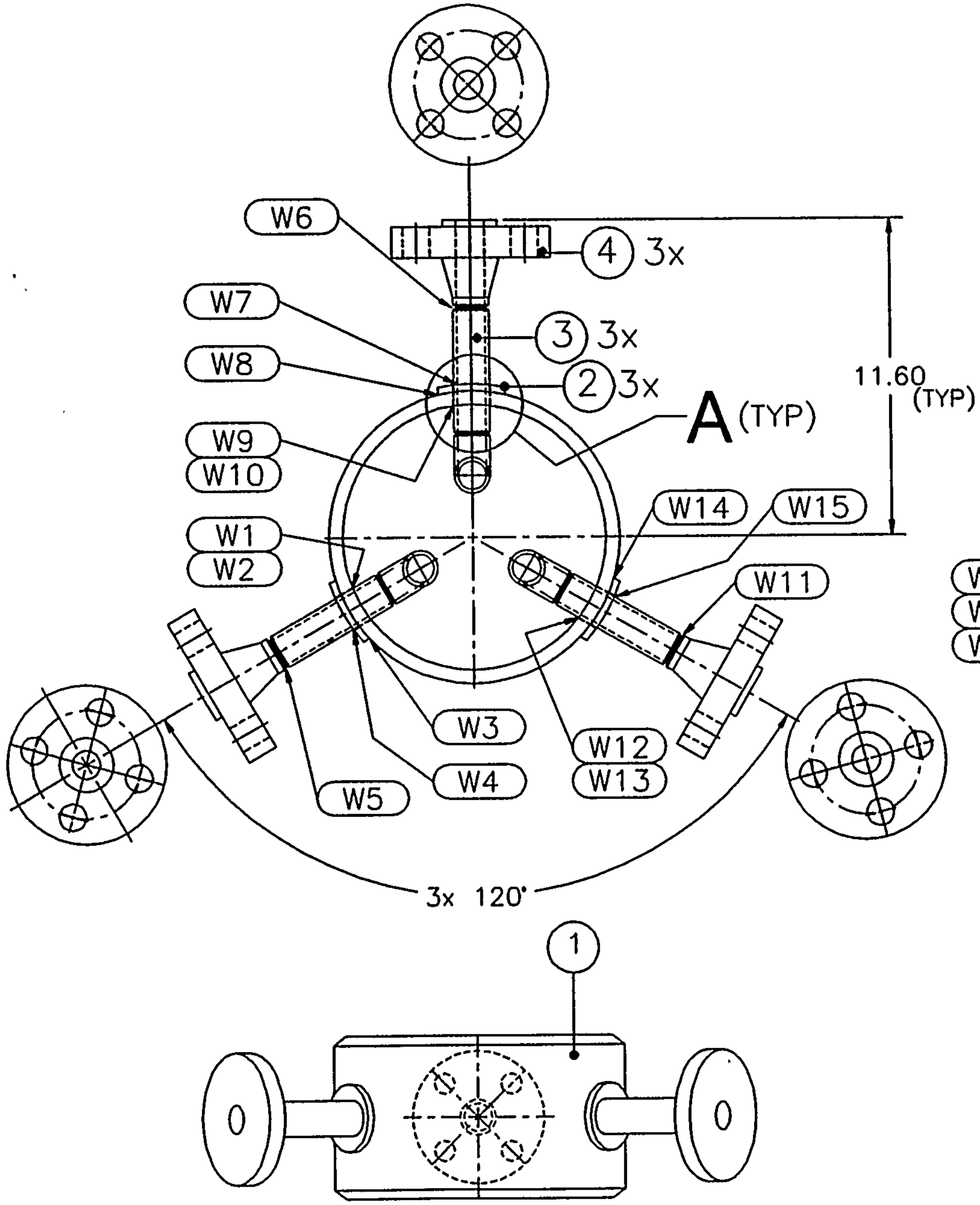
WELDMENT, BOTTOM, FILTER VESSEL, 3" PFBC

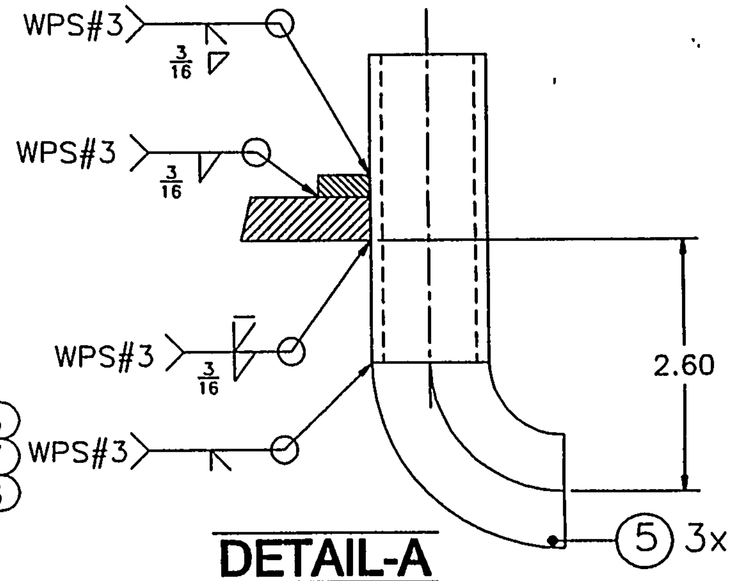
DRAWN BY: UHRICH	ESS CHK:	DATE:	W: 228 | E: 185
UNLESS SPECIFIED ALL DIMENSIONS IN INCHES	ENGR:	DATE:	FUND NO: 4261
TOLERANCES:	CLIENT:	DATE:	REV: - | SCALE: 1:1
FRACTIONAL ± 1/16; 3 PLC. DEC. ± .005; 2 PLC. DEC. ± .030; 1 PLC. DEC. ± .1; ANGULAR ± 2-1/2 DEGREES	MGR:	DATE:	SHEET 1 OF 1
	APVD:	DATE:	PRESSURE TEST DRAWING LEVEL: 1977
	FINAL ASSY: 122	NEXT ASSY: 1977	DWG. NO: 1984

1001-1J

GENERAL NOTES:

1. ALL WELDS TO BE FULL PENETRATION V-GROOVE BUTT WELDS UNLESS NOTED
2. USE WPS NO. 8 UNLESS OTHERWISE NOTED.
3. CERTIFIED WELDING IS REQUIRED AS PER ASME B31.3 EXCEPT AS NOTED.





DETAIL-A
(TYP 3x)

QTY	QTY	ITEM	PART NO	DESCRIPTION	MATERIAL SPEC	Q.C.	DATE
	3	5		ELBOW, 1"-SCH40, 90° L.R.	HAYNES ALLOY 556		
	3	4		FLANGE, 1"-1500#, RF WN	A182 F316H		
	3	3		PIPE, 1"-SCH40 x 4.6", (PREP BOTH ENDS)	HAYNES ALLOY 556		
	3	2	1988	REINFORCEMENT RING			
	1	1	1979	PIPE, MODIFIED			

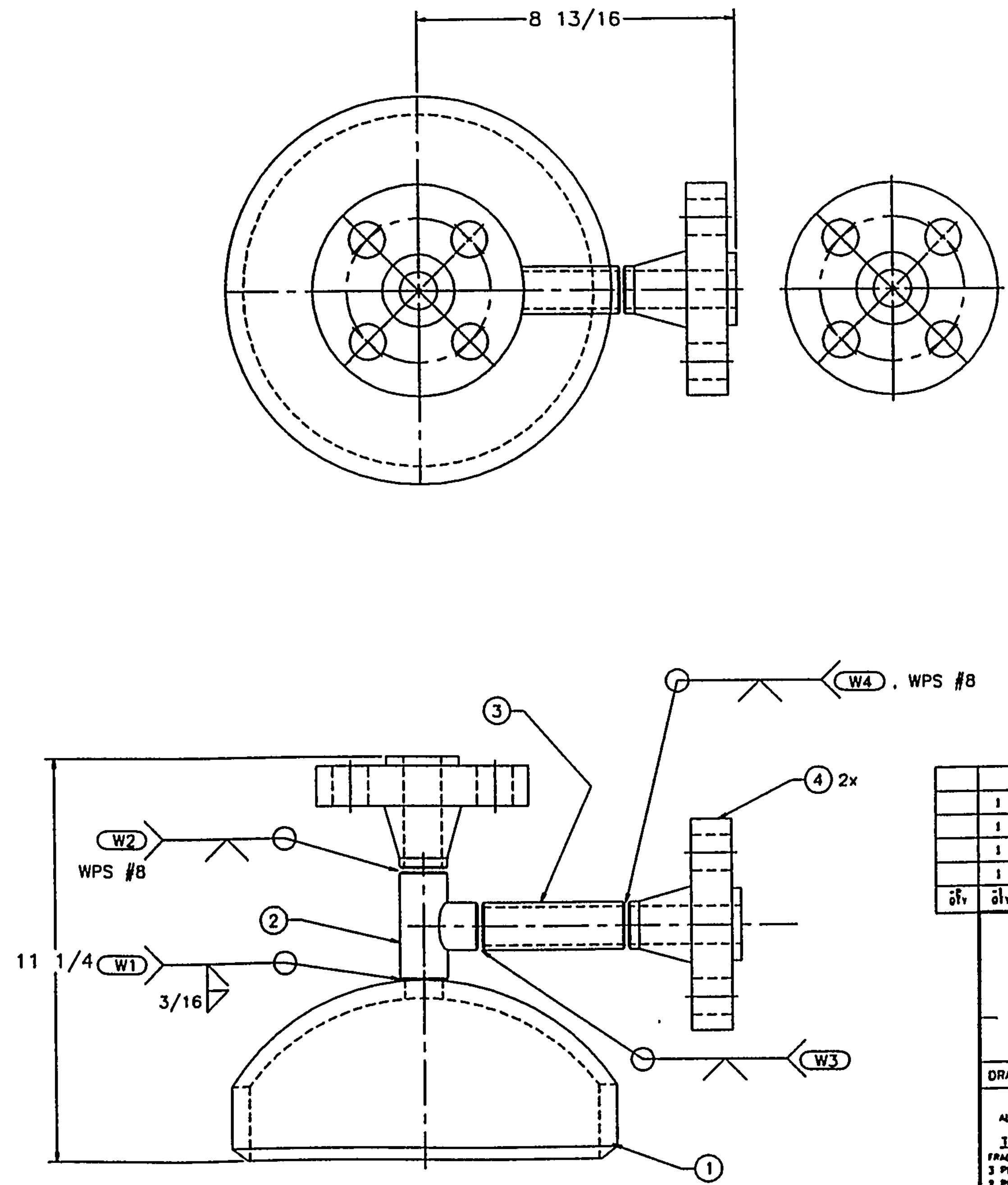
WELDMENT, TOP SECTION, FILTER VESSEL, 3" PFBC

DRAWN BY: UHRICH	ESS CHK:	DATE:	W: 228 / E: 185
UNLESS SPECIFIED ALL DIMENSIONS IN INCHES	ENGR:	DATE:	FUND NO: 4261
TOLERANCES:	CLIENT:	DATE:	REV: - / SCALE: 1:1
FRACTIONAL ± 1/16	MGR:	DATE:	SHEET 1 OF 1
3 PLC. DEC. ± 0.005; 2 PLC. DEC. ± 0.030; 1 PLC. DEC. ± 0.1	APVD:	DATE:	PRESSURE TEST DRAWING LEVEL: 1977
ANGULAR ± 2-1/2 DEGREES	FINAL ASSY: 122	NEXT ASSY: 1982	DWG. NO: 1985

1001-1J

GENERAL NOTES:

1. USE WPS NO. 3 UNLESS OTHERWISE NOTED.
2. CERTIFIED WELDING IS REQUIRED AS PER ASME B31.3 EXCEPT AS NOTED.
3. INSPECT ALL LONGITUDINAL WELDS.
4. INSPECT 5 % MIN OF CIRCUMFERENTIAL WELDS.

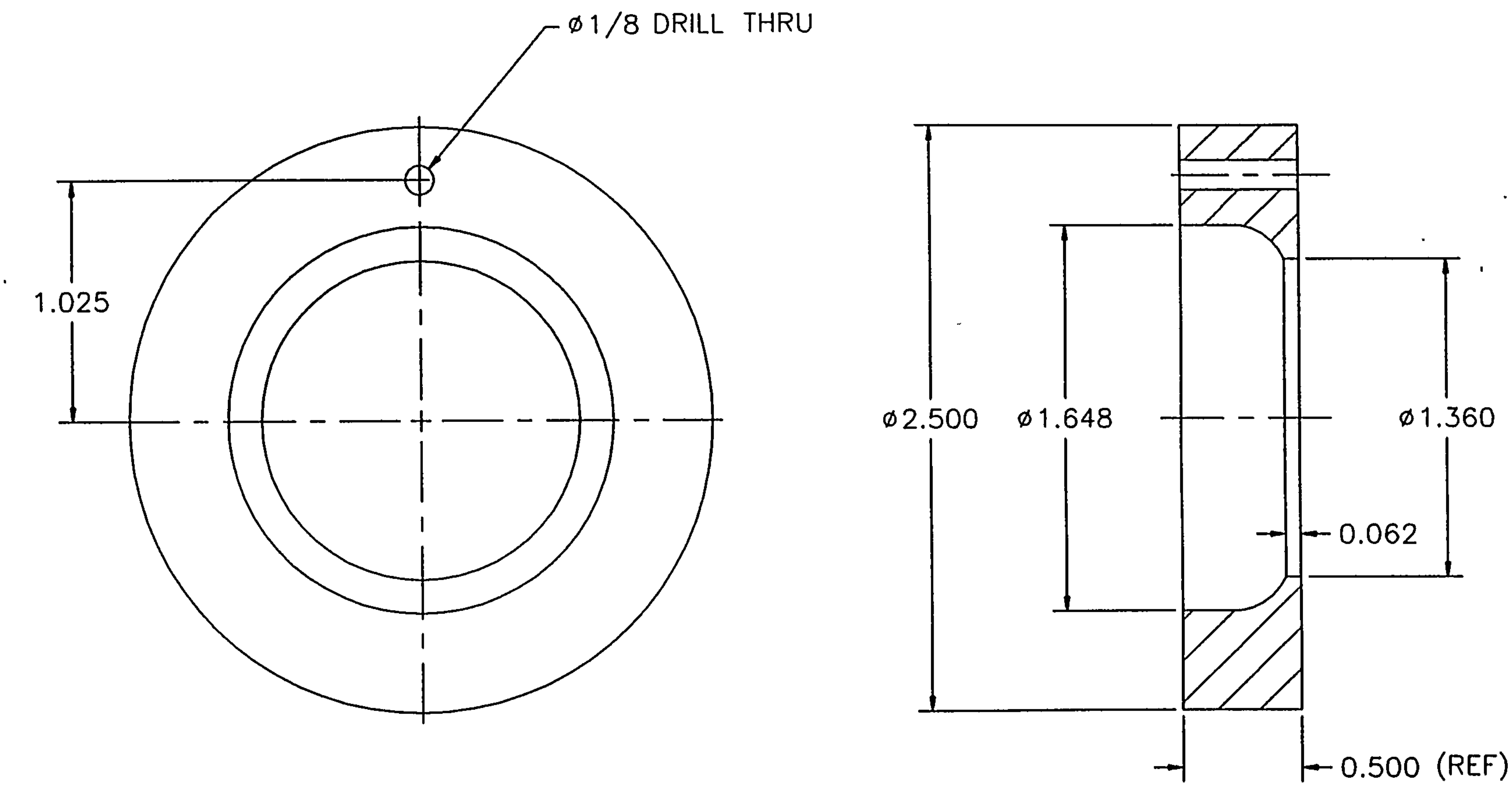


QTY	QTY	ITEM	PART NO	DESCRIPTION	MATERIAL SPEC	O.C.	DATE
		5					
	1	4		FLANGE, 1"-1500#, RF, W.N.	A182-F316H		
	1	3		PIPE, 1"-SCH40 x 4"	HAYNES ALLOY 556		
	1	2	2114	TEE, FILTER VESSEL, 3" PFBC	-		
	1	1	1978	PIPE CAP, 18" (1/2" WALL)	-		

CAP WELDMENT, FILTER VESSEL, 3" PFBC

DRAWN BY: UHRICH	ESS CHK:	DATE:	W: 228 E: 185
UNLESS SPECIFIED ALL DIMENSIONS IN INCHES	ENGR:	DATE:	FUND NO: 4261
TOLERANCES: FRACTIONAL ± 1/16; 3 PLC. DEC. ± .005; 2 PLC. DEC. ± .030; 1 PLC. DEC. ± .01; ANGULAR ± 2-1/2 DEGREES	CLIENT:	DATE:	REV: - SCALE: 1:1
	MGR:	DATE:	SHEET 1 OF 1
	APVD:	DATE:	PRESSURE TEST DRAWING LEVEL: 1977
	FINAL ASSY: 122	NEXT ASSY: 1982	DWG. NO: 1986

1001-1J

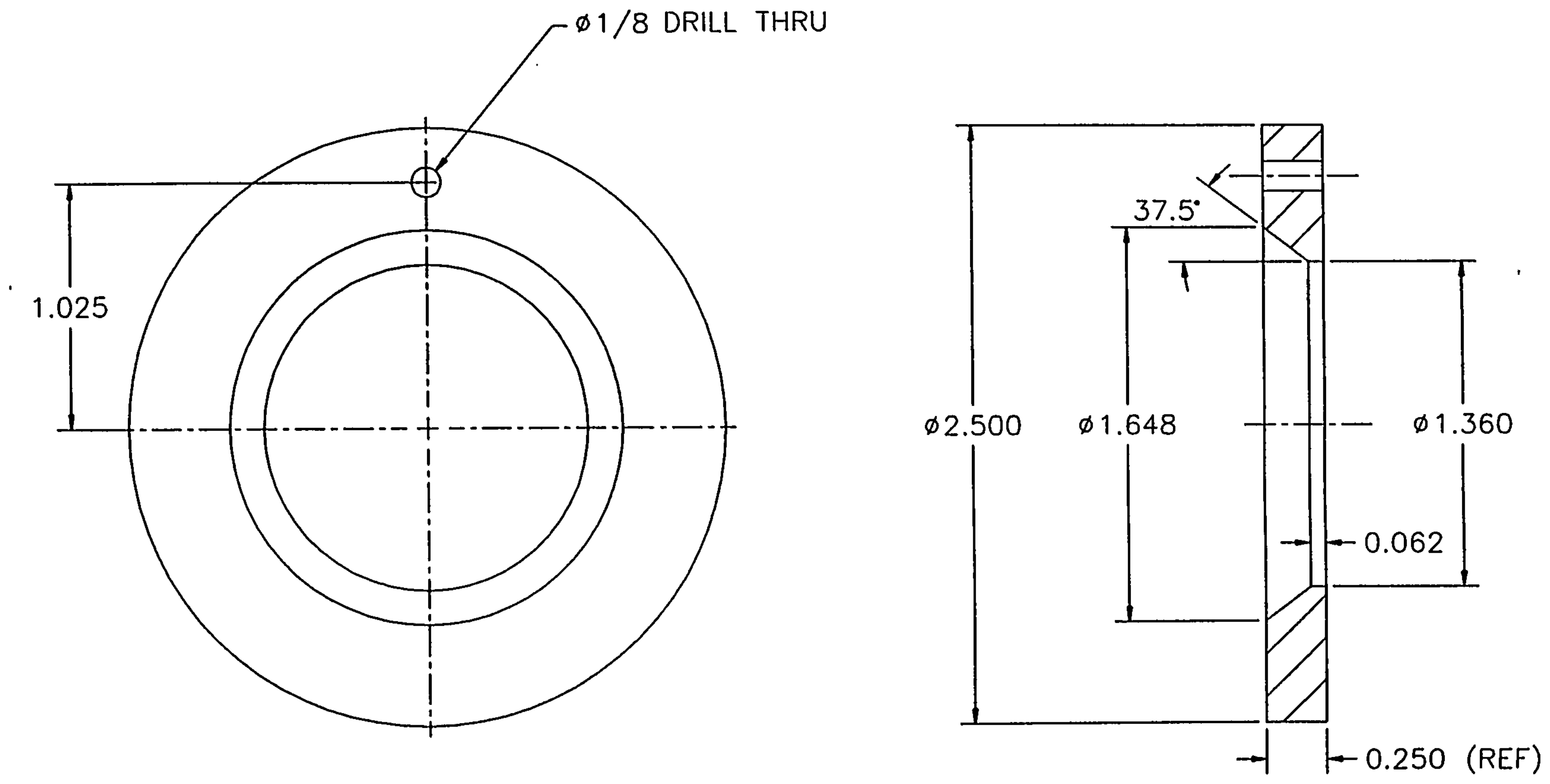


-	1	1		PLATE, 1/2"	HAYNES ALLOY 556		
QTY	QTY	ITEM	PART NO	DESCRIPTION	MATERIAL SPEC	O.C.	DATE

PAD, REINFORCEMENT, FILTER VESSEL, 3" PFBC

DRAWN BY: UHRICH	ESS CHK:	DATE:	W: V-228 E: 185
UNLESS SPECIFIED ALL DIMENSIONS IN INCHES	ENGR:	DATE:	FUND NO: 4261
TOLERANCES:	CLIENT:	DATE:	REV: - SCALE: 1:1
FRACTIONAL ± 1/16 3 PLC. DEC. ± .005 2 PLC. DEC. ± .030 1 PLC. DEC. ± .03	MGR:	DATE:	SHEET 1 OF 1
	APVD:	DATE:	PRESSURE TEST DRAWING LEVEL: 1977
ANGULAR ± 2-1/2 DEGREES	FINAL ASSY: 122	NEXT ASSY: 1984	DWG. NO: 1987

1001-1J

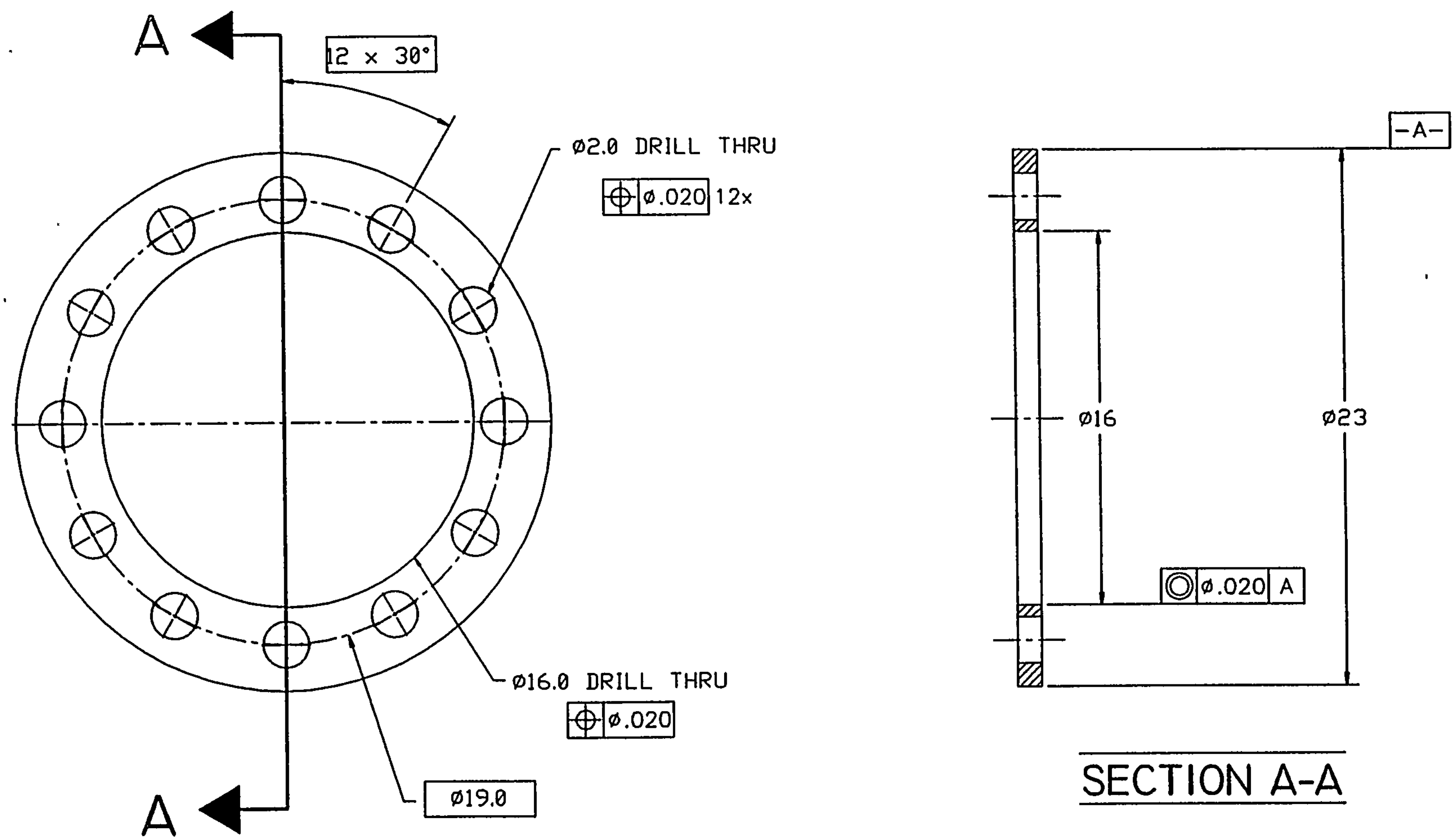


-	1	1		PLATE, 1/4"	HAYNES ALLOY 556		
QTY	QTY	ITEM	PART NO	DESCRIPTION	MATERIAL SPEC	O.C.	DATE

PAD, REINFORCEMENT, FILTER VESSEL, 3" PFBC

DRAWN BY: UHRICH	ESS CHK:	DATE:	W: V-228 E: 185
UNLESS SPECIFIED ALL DIMENSIONS IN INCHES	ENGR:	DATE:	FUND NO: 4261
TOLERANCES:	CLIENT:	DATE:	REV: - SCALE: NTS
FRACTIONAL ± 1/16	MGR:	DATE:	SHEET 1 OF 1
3 PLC. DEC. ± .005 / 2 PLC. DEC. ± .030 / 1 PLC. DEC. ± .01	APVD:	DATE:	PRESSURE TEST DRAWING LEVEL: 1977
ANGULAR ± 2-1/2 DEGREES	FINAL ASSY: 122	NEXT ASSY: 1985	DWG. NO: 1988

1001-1J

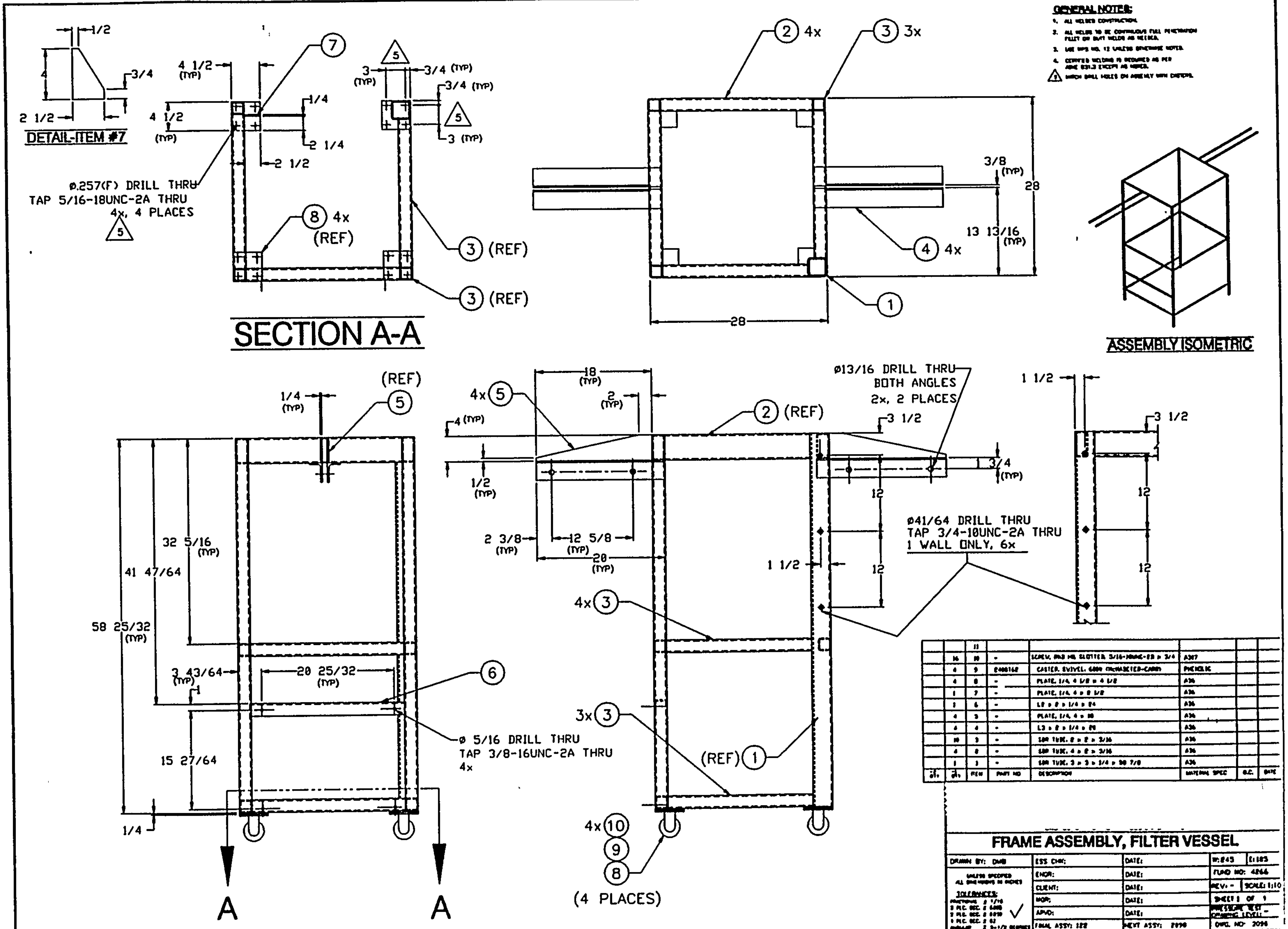


-	1	1		PLATE, 1" THICK	A240 316		
-2 QTY	-1 QTY	ITEM	PART NO	DESCRIPTION	MATERIAL SPEC	D.C.	DATE

SUPPORT PLATE, FILTER HOLDER, FILTER VESSEL, 3" PFBC

DRAWN BY: UHRICH	ESS CHK:	DATE:	W:228	E:185
UNLESS SPECIFIED ALL DIMENSIONS IN INCHES	ENGR:	DATE:	FUND NO: 4261	
TOLERANCES:	CLIENT:	DATE:	REV: -	SCALE: 1:1
FRACTIONAL ± 1/16 3 PLC. DEC. ± [illegible] 2 PLC. DEC. ± [illegible] 1 PLC. DEC. ± [illegible]	MGR:	DATE:	SHEET 1 OF 1	
✓	APVD:	DATE:	PRESSURE TEST DRAWING LEVEL: 1977	
ANGULAR ± 2-1/2 DEGREES	FINAL ASSY: 122	NEXT ASSY: 1977	DWG. NO: 1989	

1001-1J



GENERAL NOTES:

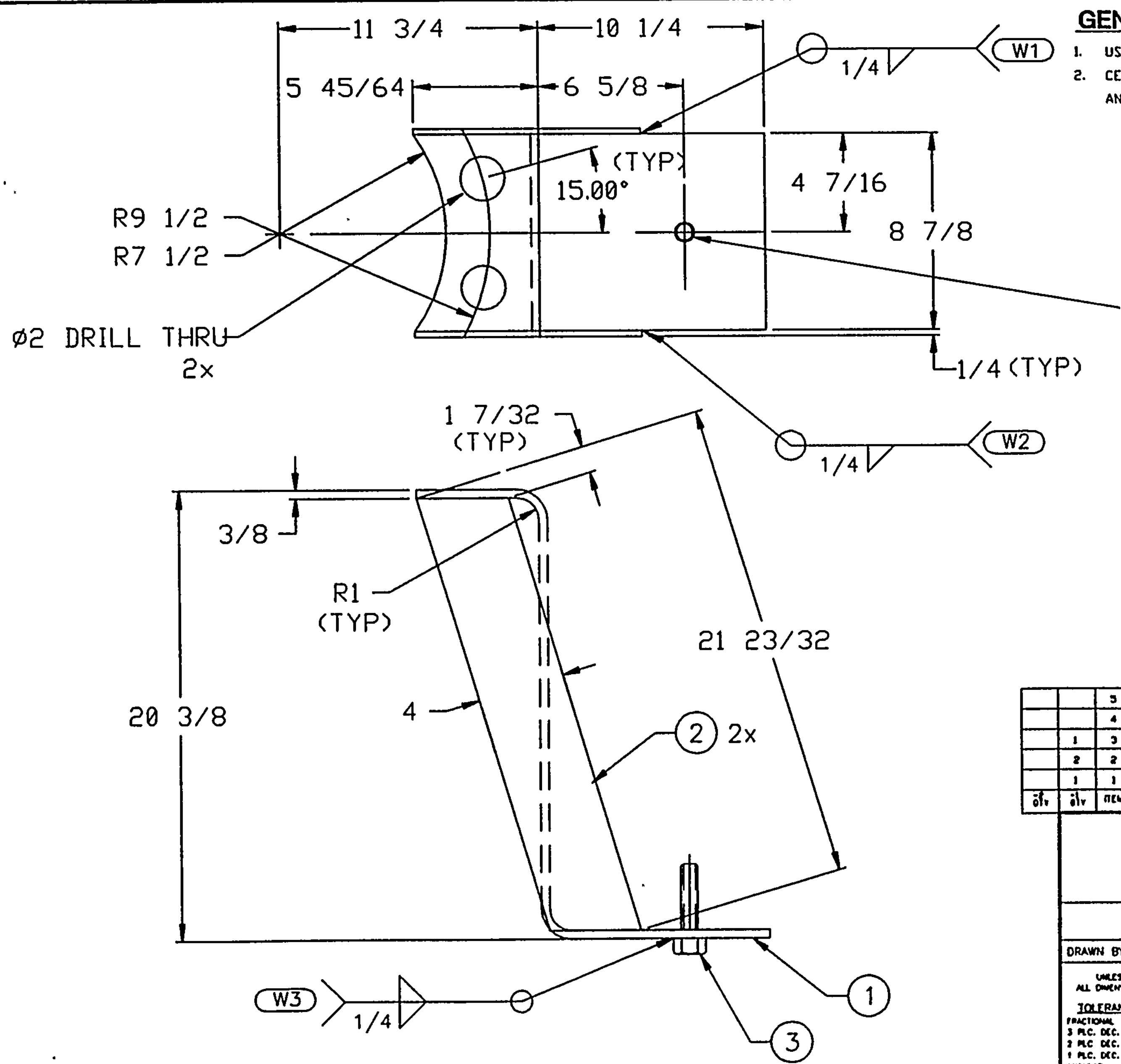
1. ALL WELDED CONSTRUCTION.
2. ALL WELDS TO BE CONTINUOUS FULL PENETRATION FILLET OR BUTT WELDS AS NEEDED.
3. USE WPS NO. 12 UNLESS OTHERWISE NOTED.
4. CERTIFIED WELDING IS REQUIRED AS PER ASME B31.3 EXCEPT AS NOTED.
5. (△) MATCH DRILL HOLES ON ASSEMBLY WITH CASTERS.

QTY	QTY	ITEM	PART NO	DESCRIPTION	MATERIAL SPEC	Q.C.	DATE
		11					
	16	10	-	SCREW, PAN HD SLOTTED, 5/16-18UNC-2B x 3/4	A307		
	4	9	[illegible]	CASTER, SWIVEL, 6000 (MCMASTER-CARR)	PHENOLIC		
	4	8	-	PLATE, 1/4, 4 1/2 x 4 1/2	A36		
	1	7	-	PLATE, 1/4, 4 x 8 1/2	A36		
	1	6	-	L2 x 2 x 1/4 x 24	A36		
	4	5	-	PLATE, 1/4, 4 x 18	A36		
	4	4	-	L3 x 2 x 1/4 x 28	A36		
	10	3	-	SQR TUBE, 2 x 2 x 3/16	A36		
	4	2	-	SQR TUBE, 4 x 2 x 3/16	A36		
	1	1	-	SQR TUBE, 3 x 3 x 1/4 x 58 7/8	A36		

FRAME ASSEMBLY, FILTER VESSEL

DRAWN BY: DMB	ESS CHK:	DATE:	W:243	E:183
UNLESS SPECIFIED ALL DIMENSIONS IN INCHES	ENGR:	DATE:	FUND NO: 4266	
TOLERANCES:	CLIENT:	DATE:	REV: -	SCALE: 1:10
FRACTIONS ± 1/16	MOP:	DATE:	SHEET 1 OF 1	
3 PLC. DEC. ± .005; 2 PLC. DEC. ± .010; 1 PLC. DEC. ± .02; ANGULAR ± 0-1/2 DEGREES ✓	APVD:	DATE:	PRESSURE TEST - OPERATING LEVEL -	
	FINAL ASSY: 122	NEXT ASSY: 2090	DWG. NO: 2098	

1003-11



GENERAL NOTES:

1. USE WPS NO. 12 UNLESS OTHERWISE NOTED.
2. CERTIFIED WELDING IS REQUIRED AS PER ANSI/AWS D1.1. EXCEPT AS NOTED.

QTY	QTY	ITEM	PART NO	DESCRIPTION	MATERIAL SPEC	Q.C.	DATE
		5					
		4					
1	3	3	-	BOLT, HEX NO. 3/4-10UNC-2B x 3 1/2	A193-B7		
2	2	2	-	PLATE, 1/4 x 4	A36		
1	1	1	-	PLATE, 3/8 x 8-7/8	A36		

BRACKET, HANGER, FILTER VESSEL

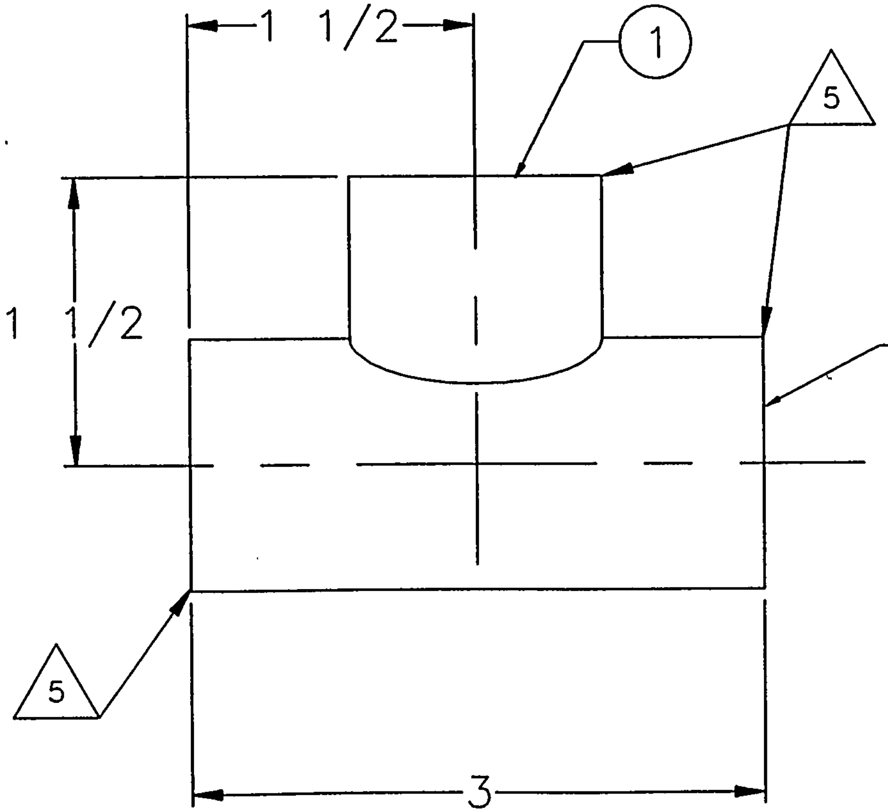
DRAWN BY: DMB	ESS CHK:	DATE:	W:245 E:185
UNLESS SPECIFIED ALL DIMENSIONS IN INCHES	ENGR:	DATE:	FUND NO: 4266
TOLERANCES:	CLIENT:	DATE:	REV: - SCALE: 1:5
FRACTIONAL ± 1/16	MGR:	DATE:	SHEET 1 OF 1
3 PLC. DEC. ± .005; 2 PLC DEC. ± .030; 1 PLC. DEC. ± .01	APVD:	DATE:	PRESSURE TEST DRAWING LEVEL: -
ANGULAR ± 2-1/2 DEGREES	FINAL ASSY: 122	NEXT ASSY: 2098	DWG. NO: 2097

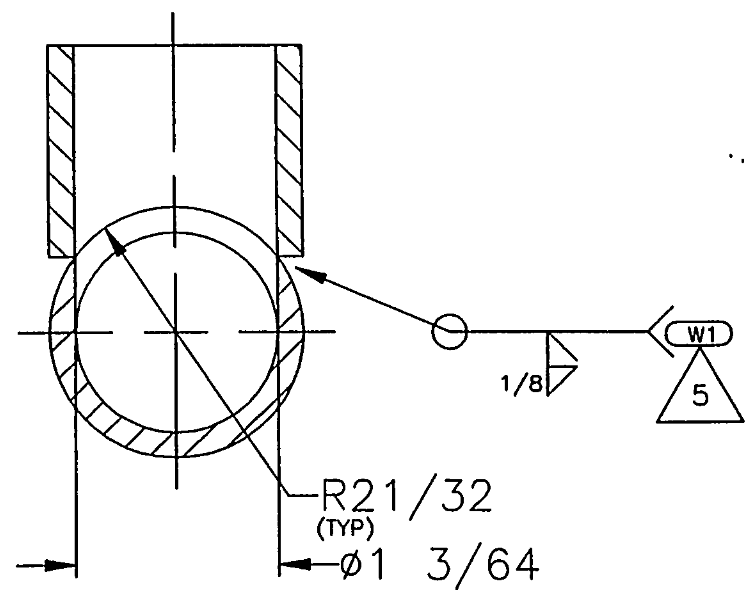
1002-1J

GENERAL NOTES:

1. USE WPS NO. 3 UNLESS OTHERWISE NOTED.
2. CERTIFIED WELDING IS REQUIRED AS PER ASME B31.3 EXCEPT AS NOTED.
3. INSPECT ALL LONGITUDINAL WELDS.
4. INSPECT 5 % MIN OF CIRCUMFERENTIAL WELDS.

△5 WELD PREP PIPE ENDS



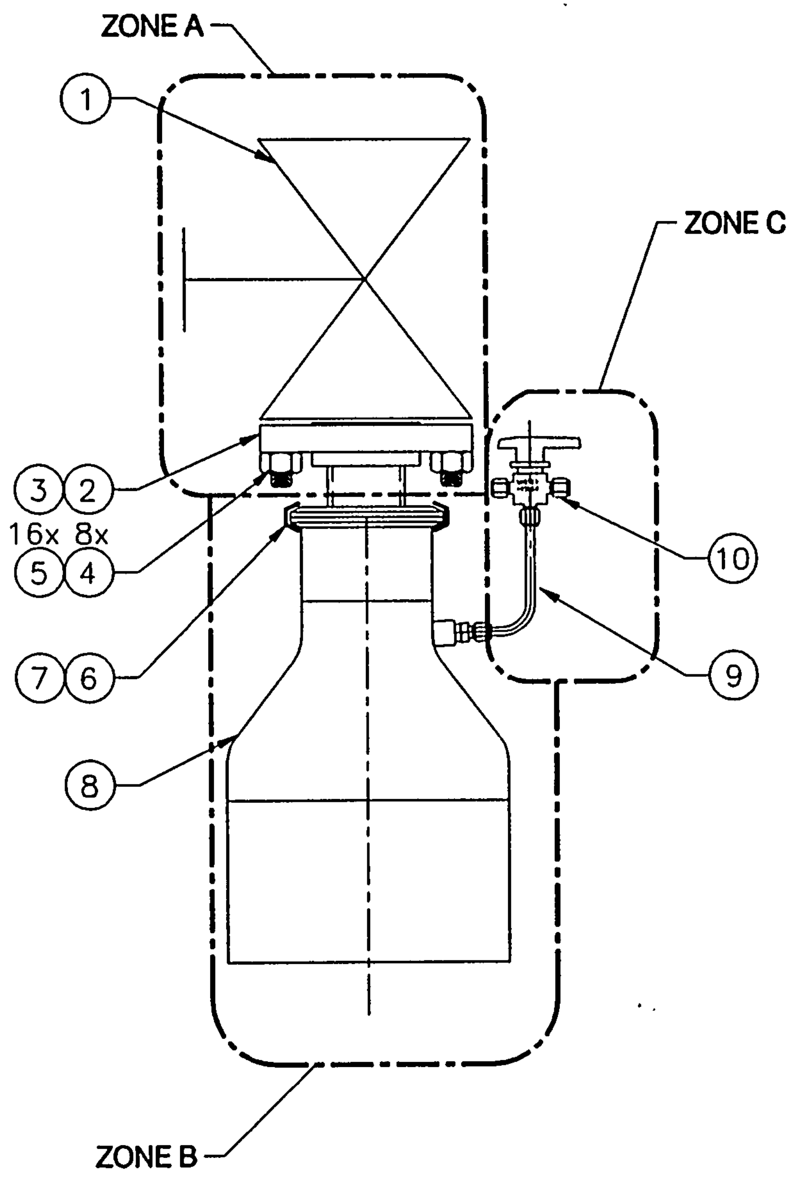


QTY	QTY	ITEM	PART NO	DESCRIPTION	MATERIAL SPEC	Q.C.	DATE
		3					
		2					
	2	1	-	PIPE, 1"-SCH 40	HAYNES ALLOY 556		

TEE, REINFORCED, FILTER VESSEL, 3"PFBC

DRAWN BY: DMB	ESS CHK:	DATE:	W:228	E:-185
UNLESS SPECIFIED ALL DIMENSIONS IN INCHES	ENGR:	DATE:	FUND NO: 4261	
TOLERANCES:	CLIENT:	DATE:	REV: -	SCALE: 1:1
FRACTIONAL ± 1/16 3 PLC. DEC. ± .0005 2 PLC. DEC. ± .0030 1 PLC. DEC. ± .01	MGR:	DATE:	SHEET 1 OF 1	
	APVD:	DATE:	PRESSURE TEST DRAWING LEVEL: 1977	
ANGULAR ± 2-1/2 DEGREES	FINAL ASSY: 122	NEXT ASSY: 1986	DWG. NO: 2114	

1001-1J



GENERAL NOTES:

1. USE WPS NO. 1 UNLESS OTHERWISE NOTED.
2. CERTIFIED WELDING IS REQUIRED AS PER ASME B31.3 EXCEPT AS NOTED.

DESIGN PARAMETERS

DESIGN ZONE	PRESSURE		DESIGN TEMP MAX	DESIGN TEMP MIN	CORROSION ALLOWANCE	OPERATING FLUID
A	160	MAWP PSI	300 F	-20 F	-.03 INCHES	CHAR ASH
	150	MOP PSI	300 F	-20 F		
B	160	MAWP PSI	200 F	-20 F	-.03 INCHES	CHAR ASH
	150	MOP PSI	200 F	-20 F		
C	160	MAWP PSI	75 F	-20 F	-.03 INCHES	CHAR ASH
	150	MOP PSI	75 F	-20 F		

DESIGN [A] LIMITED BY: VALVE, ITEM # 1
DESIGN [B] LIMITED BY: ITEM# 8 AT BRANCH ATTACHMENT
DESIGN [C] LIMITED BY: ITEM#S 12 & 13, QUICK CONNECTORS
DESIGN RATING BASED ON ASME B31.3.

PRESSURE TEST

TEST ZONE	TEST PRESSURE	TEST TEMPERATURE	TEST FLUID
ALL	240 PSI MAX	75 °F	D.I. H_2O

DESIGN LIMITED BY: ITEM# 8 AT BRANCH ATTACHMENT
DESIGN RATING BASED ON ASME B31.3.

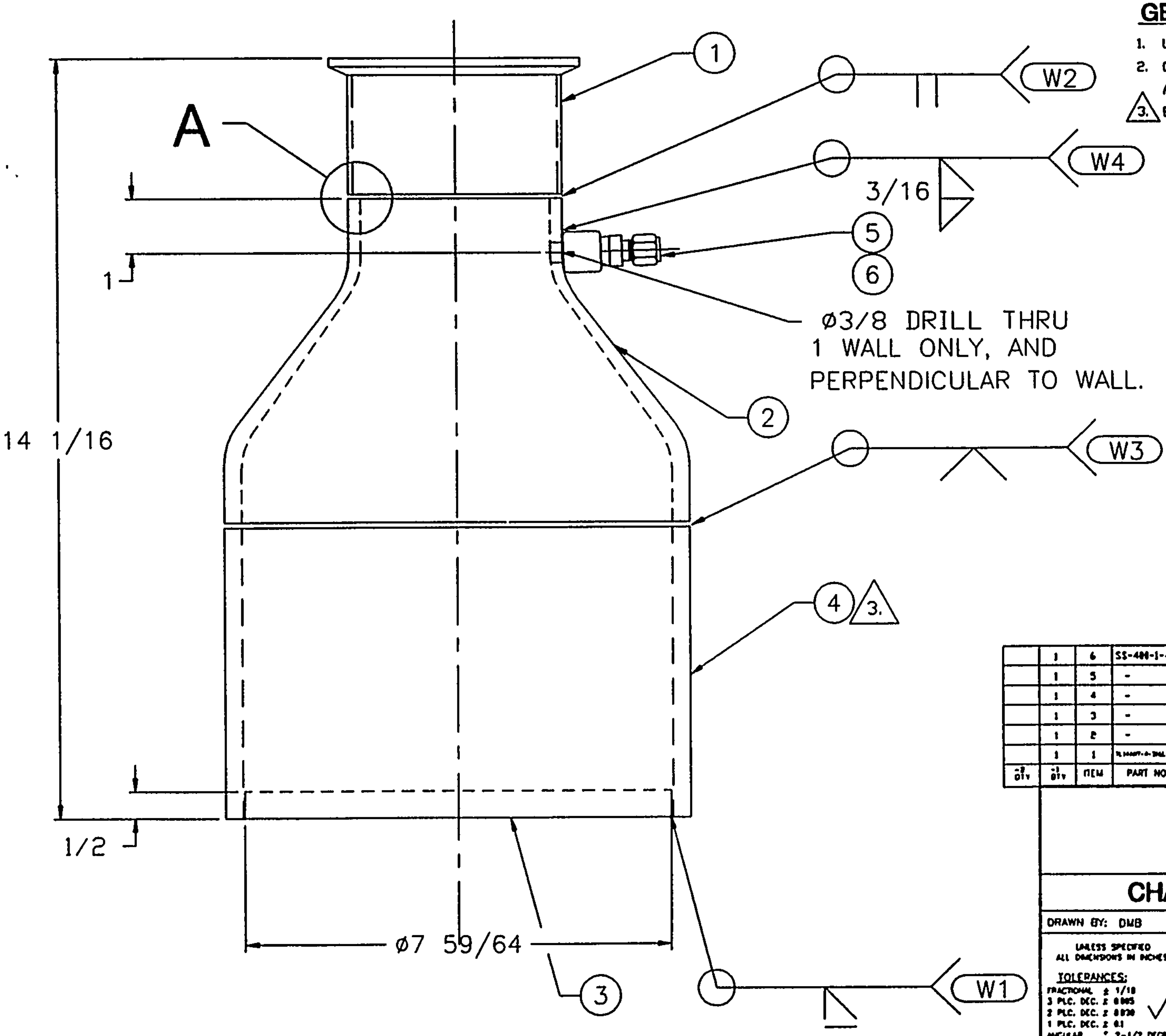
		12					
		11					
	1	10	SS-43XS4	VALVE, 3 WAY, BALL, 1/4" (WHITEY)	316 SS		
	1	9	-	TUBE, 1/4 x .035	A213-TP304L		
	1	8	2117	CHAR POT, FILTER VESSEL, 3" PFBC	-		
	1	7	13MHHS-4	CLAMP, 4" (TRI-CLOVER)	304 SS		
	1	6	40MP-SFY-4	GASKET, 4" (TRI-CLOVER)	VITON		
	16	5	-	NUT, HEAVY HEX, 5/8-11UNC-2B	A194 Gr.2H		
	8	4	-	STUD BOLT, 5/8-11UNC-2A x 3-1/2	A193-B7		
	1	3	2116	SPOOL PIECE, CHAR POT, FILTER VESSEL, 3" PFBC			
	1	2	CG-3G	GASKET, SPIRAL WOUND, 2"-300# (FLEXITALIC)	304 SS		
	1	1	9289769	VALVE, PLUG, 2" WITH WATER JACKET (DE-ZURIK)	316		
QTY	QTY	ITEM	PART NO	DESCRIPTION	MATERIAL SPEC.	Q.C.	DATE

CHAR POT ASSEMBLY, FILTER VESSEL, 3" PFBC

DRAWN BY: DMB	ESS CHK:	DATE:	W:228 E:185
UNLESS SPECIFIED ALL DIMENSIONS IN INCHES	ENGR:	DATE:	FUND NO: 4669
TOLERANCES: FRACTIONAL ± 1/16; 3 PLC. DEC. ± .005; 2 PLC. DEC. ± .030; 1 PLC. DEC. ± .01; ANGULAR ± 2-1/2 DEGREES	CLIENT:	DATE:	REV: - SCALE: 1:4
	MGR:	DATE:	SHEET 1 OF 1
	APVD:	DATE:	PRESSURE TEST DRAWING LEVEL: 2115
	FINAL ASSY: 122	NEXT ASSY: -	DWG. NO: 2115

2115

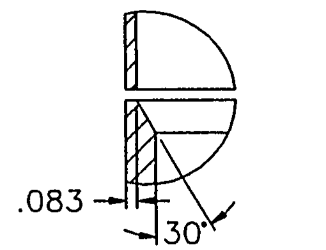
1002-1J



GENERAL NOTES:

1. USE WPS NO. 1 UNLESS OTHERWISE NOTED.
2. CERTIFIED WELDING IS REQUIRED AS PER ASME B31.3 EXCEPT AS NOTED.
3. (triangle) ETCH USING 1/8" LETTERING - P/N 2117
   - MAWP 160 PSI @ 300°F
   - SERIAL # (SEE INSPECTION SHEET

REV	ECN	DATE
A	W228	8-17-96
B		
C		



DETAIL-A

QTY	QTY	ITEM	PART NO	DESCRIPTION	MATERIAL SPEC	Q.C.	DATE
	1	6	SS-400-1-4	[illegible]	304 SS		
	1	5	-	COUPLING, THREADED, HALF, 1/4"-3000#	A182-F316		
	1	4	-	PIPE, 8" SCH 40	TP312-304		
	1	3	-	PLATE, 1/2 x Ø7-15/16	A240-304L		
	1	2	-	REDUCER, CONCENTRIC, 8" x 3-1/2"	A403-WP304		
	1	1	[illegible]	SPUD, 4", TANK WELD (TRI-CLOVER)	316L		

CHAR POT, FILTER VESSEL, 3" PFBC

DRAWN BY: DMB	ESS CHK:	DATE:	W:228 E:185
UNLESS SPECIFIED ALL DIMENSIONS IN INCHES	ENGR:	DATE:	FUND NO: 4669
TOLERANCES: FRACTIONAL ± 1/16; 3 PLC. DEC. ± .005; 2 PLC. DEC. ± .030; 1 PLC. DEC. ± .1; ANGULAR ± 2-1/2 DEGREES	CLIENT:	DATE:	REV: A SCALE: 1:2
	MGR:	DATE:	SHEET 1 OF 1
	APVD:	DATE:	PRESSURE TEST DRAWING LEVEL: 2115
	FINAL ASSY: 122	NEXT ASSY: 2115	DWG. NO: 2117

1002-1J

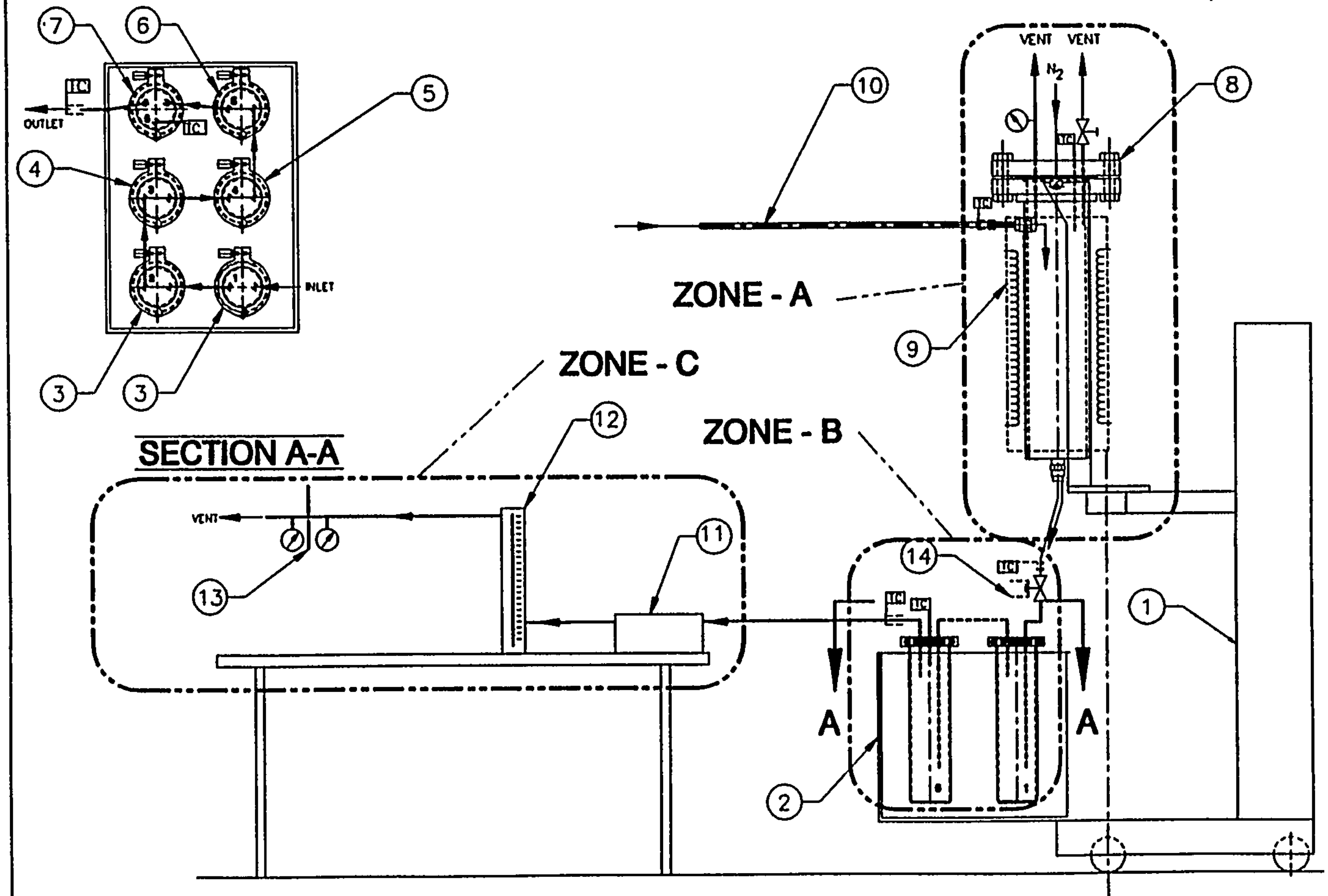
APPENDIX B

DETAILED CONSTRUCTION DRAWINGS FOR HIGH-PRESSURE, HIGH-TEMPERATURE SAMPLING SYSTEM

GENERAL NOTES:

(pressure gauge symbol) = PRESSURE GAUGE (TYP)

TC = THERMOCOUPLE (TYP)



DESIGN PARAMETERS

DESIGN ZONE	PRESSURE		DESIGN TEMP MAX	DESIGN TEMP MIN	CORROSION ALLOWANCE	OPERATING FLUID
A	200	PSI	1000 F	32 F	0 INCHES	FLUE GAS
	120	MOP PSI	800 F	32 F		
B	200	PSI	280 F	32 F	0 INCHES	FLUE GAS
	120	MOP PSI	180 F	32 F		
C	35	PSI	120 F	32 F	0 INCHES	FLUE GAS
	10	MOP PSI	80 F	32 F		

DESIGN [A] LIMITED BY: ITEM # 14, CONTROL VALVE
DESIGN [B] LIMITED BY: TEFLON GASKET & FLANGE CLAMPS
DESIGN [C] LIMITED BY: ITEM # 12, FLOW METER
DESIGN RATING BASED ON ASME B31.3.

PRESSURE TEST

TEST ZONE	TEST PRESSURE	TEST TEMPERATURE	TEST FLUID
A	600 PSI	72 °F	H_2O
B	330 PSI	72 °F	H_2O
C	36 PSI	72 °F	AIR

DESIGN [A] LIMITED BY: ITEM # 14, CONTROL VALVE
DESIGN [B] LIMITED BY: TEFLON GASKET & FLANGE CLAMPS
DESIGN [C] LIMITED BY: ITEM # 12, FLOW METER
DESIGN RATING BASED ON ASME B31.3.

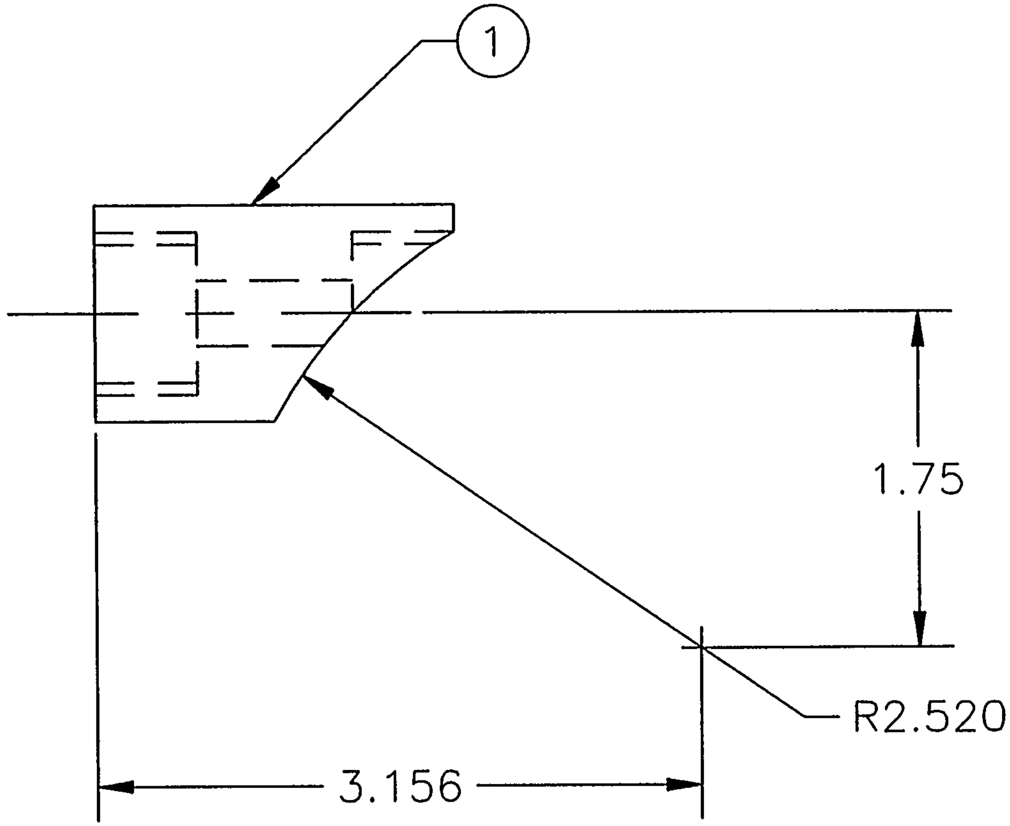
QTY	QTY	ITEM	PART NO	DESCRIPTION	MATERIAL SPEC
		16			
		15			
	1	14	6-Z-ULP-6-SS	FLOW CONTROL VALVE (PARKER)	
	1	13	–	ORIFICE METER (EERC)	
	1	12	RMC-122-SSTB	FLOW METER (DWYER)	
	1	11	–	OIL TRAP WITH INDICATOR	
	1	10	–	SAMPLE PROBE ASSEMBLY	
	2	9	VS-05A-24T	HEATER, SPLIT SHELL CERAMIC (WATLOW)	
	1	8	1071	PARTICULATE SAMPLING ASSEMBLY	
	1	7	1078-2	ADSORBER, MOLECULAR SEIVE	
	1	6	1078-1	ADSORBER, ACTIVATED CARBON	
	1	5	1078-1	BUBBLER, SILCA GELL	
	1	4	1078-1	BUBBLER, DRY	
	2	3	1078-1	BUBBLER, SOLUTION	
	1	2		BOX	
	1	1	–	POSITIONING JACK, 2 STAGE PORTABLE	

REV		DATE
A		4-22-93
B		
C		

PARTICULATE SAMPLER ASSEMBLY

UNLESS SPECIFIED ALL DIMENSIONS IN INCHES TOLERANCES: FRACTIONAL ± 1/8; 3 PLC. DEC. ± 0.005; 2 PLC. DEC. ± 0.030; 1 PLC. DEC. ± 0.1; ANGULAR ± 2-1/2 DEGREES	DRAWN: DMB	DATE: 4-22-93	FUND NO: 4358
	CHECKED:	DATE:	WORK REQ: W1
	ENGINEER:	DATE:	REV: A / SCALE: NTS
	MANAGER:	DATE:	SHEET 1 OF 1
	APP BY:	DATE:	PRESSURE TEST DRAWING LEVEL: –
	FINAL ASSY: –	NEXT ASSY: –	DWG. NO: 1078

1138

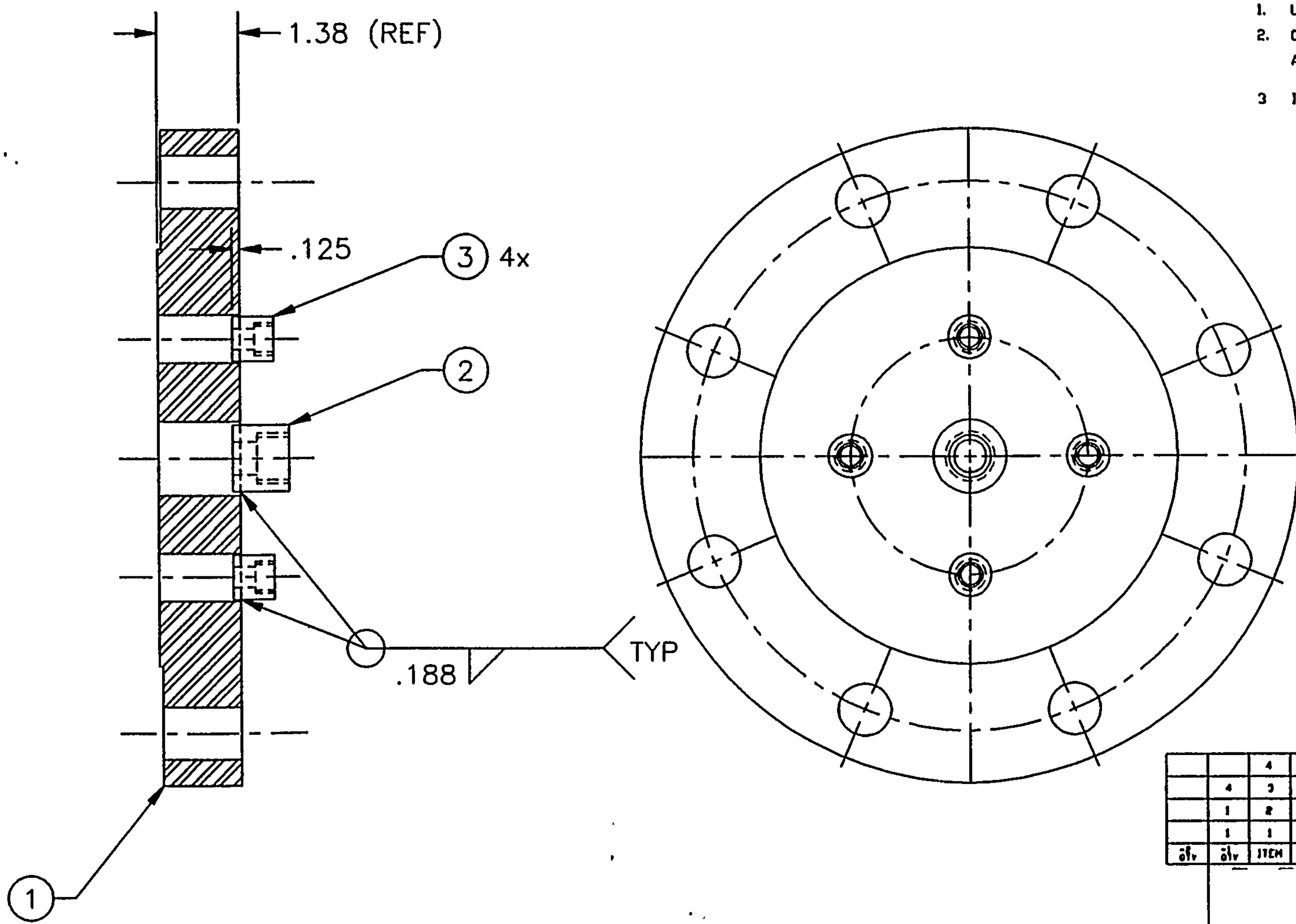


QTY	QTY	ITEM	PART NO	DESCRIPTION	MATERIAL SPEC
		2			
	1	1		PIPE COUPLING, .5 - 18 NPT - 3000#	A182-F316L

COUPLING, MODIFIED, 1/2 NPT – 3000#

UNLESS SPECIFIED ALL DIMENSIONS IN INCHES TOLERANCES: FRACTIONAL ± 1/16, 3 PLC. DEC. ± .005, 2 PLC. DEC. ± .030, 1 PLC. DEC. ± .01, ANGULAR ± 2-1/2 DEGREES	DRAWN: DMB	DATE: 4-7-92	FUND NO: 4358
	CHECKED: GLS	DATE: 4-9-92	WORK REQ: W7
	MANAGER:	DATE:	REV: – SCALE: 1:1
	APP BY:	DATE:	SHEET 1 OF 1
	FINAL ASSY: 1076	NEXT ASSY: 1074	DWG. NO: 1138

1001–D



GENERAL NOTES:

1. USE WPS NO. 1 UNLESS OTHERWISE NOTED.
2. CERTIFIED WELDING IS REQUIRED AS PER ASME B31.3 EXCEPT AS NOTED.
3. INSPECT 5 % MIN OF CIRCUMFERENTIAL WELDS.

		4			
	4	3		PIPE COUPLING HALF, .25-18 NPT 3000#	A182-F316L
	1	2		PIPE COUPLING HALF, .5-14 NPT 3000#	A182-F316L
	1	1	1073	FLANGE, MODIFIED 5"-300# BLIND	
QTY	QTY	ITEM	PART NO	DESCRIPTION	MATERIAL SPEC

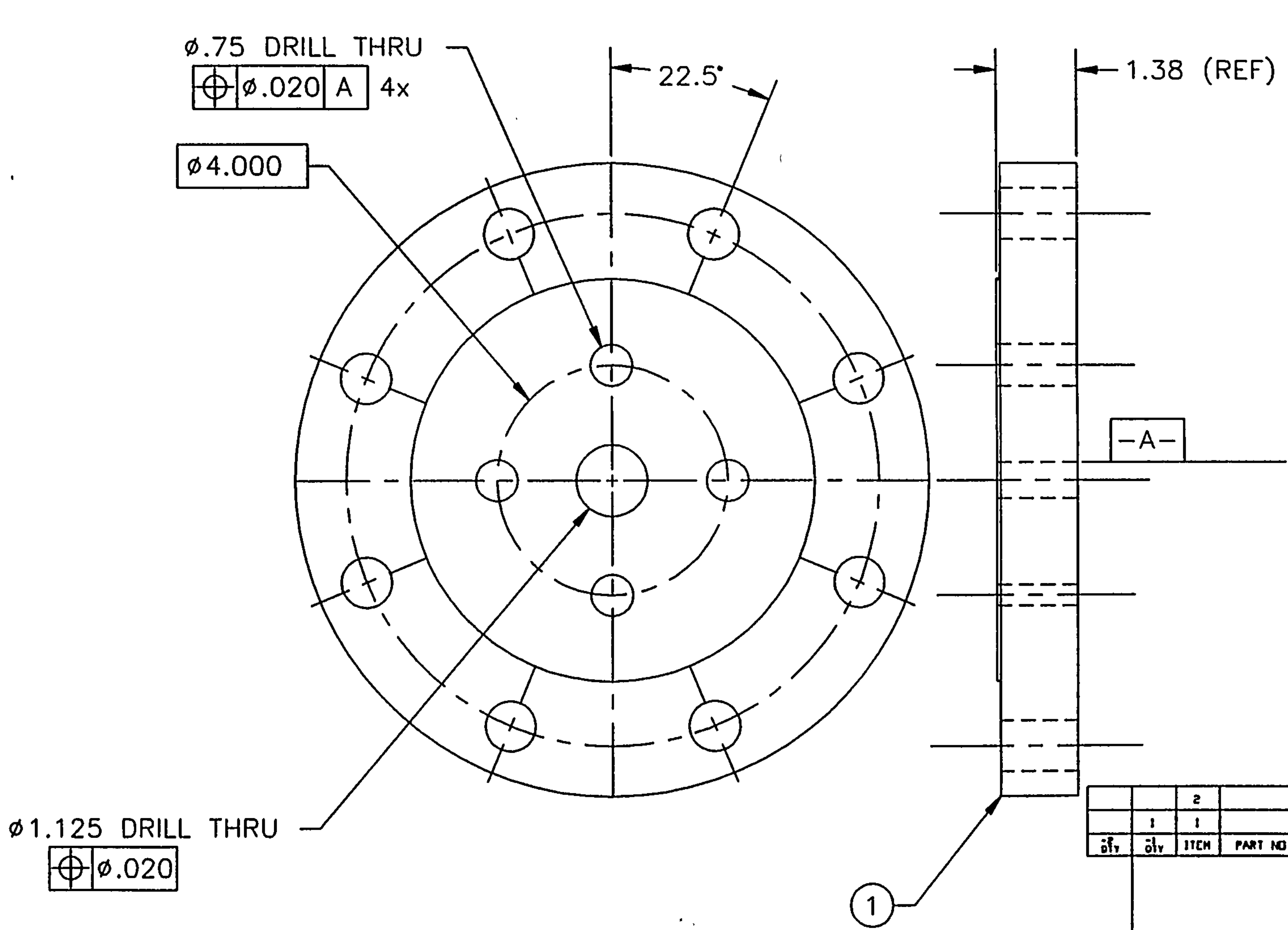
HEAD WELDMENT

UNLESS SPECIFIED ALL DIMENSIONS IN INCHES TOLERANCES: FRACTIONAL ± 1/16; 3 PLC. DEC. ± .005; 2 PLC. DEC. ± .030; 1 PLC. DEC. ± .1; ANGULAR ± 2-1/2 DEGREES ✓	DRAWN: DMB	DATE: 4-1-92	FUND NO: 4358
	CHECKED: ?	DATE: ?	WORK REQ: W7
	MANAGER:	DATE:	REV: - SCALE: 1:2
	APP BY:	DATE:	SHEET 1 OF 1
	FINAL ASSY: 1071	NEXT ASSY: -	DWG. NO: 1072

1002-C

1873

REV	WORK REQ #	DATE
A	?	?
B	?	?
C	?	?



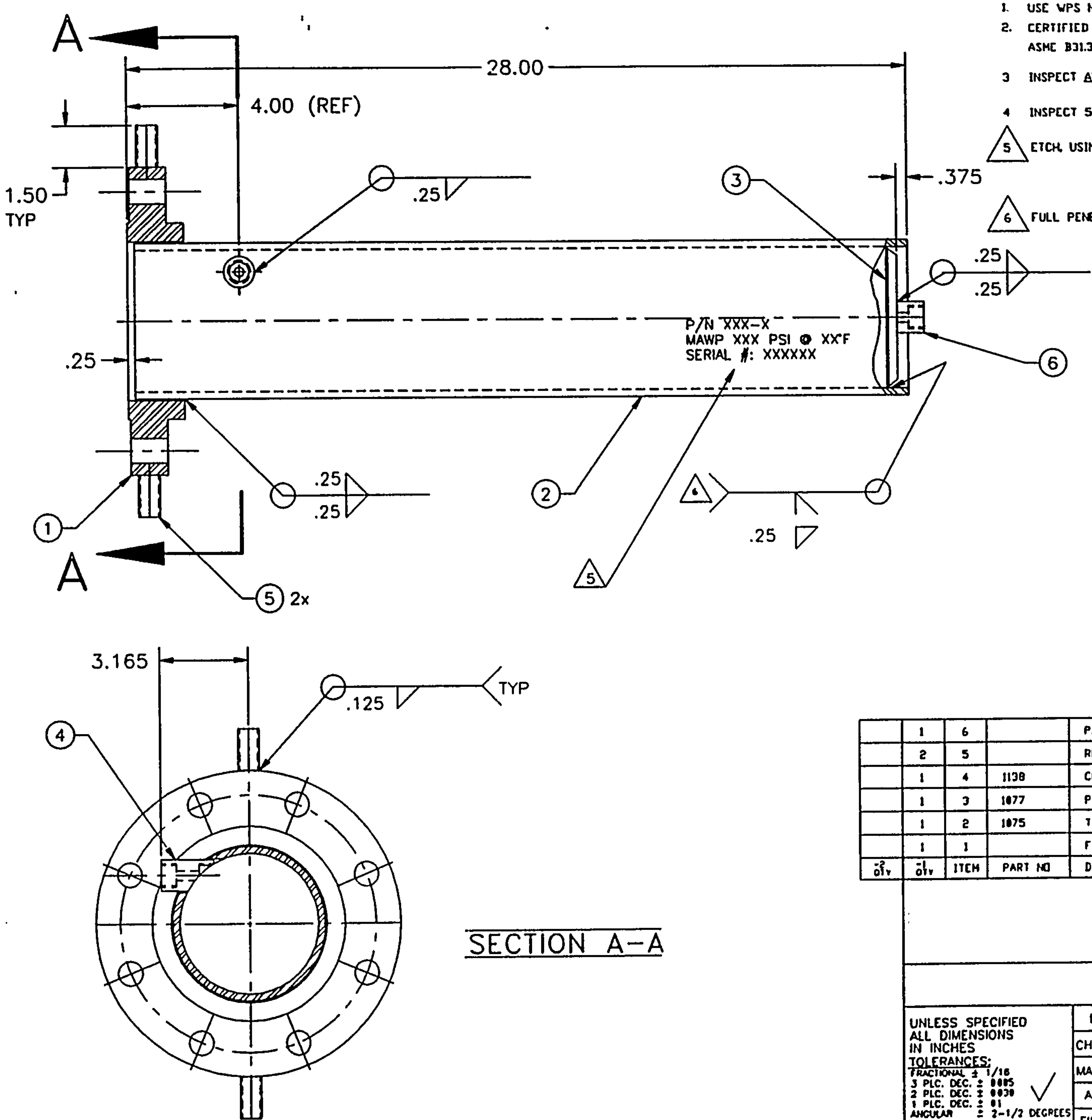
		2			
	1	1		FLANGE, BLIND, RF, 5"-300#	A182-F316L
QTY	QTY	ITEM	PART NO	DESCRIPTION	MATERIAL SPEC

FLANGE, MODIFIED, 5"–300# BLIND

UNLESS SPECIFIED
ALL DIMENSIONS
IN INCHES
TOLERANCES:
FRACTIONAL ± 1/16
3 PLC. DEC. ± .005
2 PLC. DEC. ± .030
1 PLC. DEC. ± .01
ANGULAR ± 2-1/2 DEGREES

DRAWN: DMB	DATE: 3-30-92	FUND NO: 4358	
CHECKED: GLS	DATE: 4-9-92	WORK REQ: W7	
MANAGER:	DATE:	REV: -	SCALE: 1:2
APP BY:	DATE:	SHEET 1 OF 1	
FINAL ASSY: 1871	NEXT ASSY: 1872	DWG. NO: 1873	

1002-C



GENERAL NOTES:

1. USE WPS NO. 1 UNLESS OTHERWISE NOTED.
2. CERTIFIED WELDING IS REQUIRED AS PER ASME B31.3 EXCEPT AS NOTED.
3. INSPECT ALL LONGITUDINAL WELDS.
4. INSPECT 5 % MIN OF CIRCUMFERENTIAL WELDS.

△5 ETCH, USING .125 LETTERING " P/N 1071
MAWP 300 PSI @ 1000°F
SERIAL #: (SEE INSPECTION CHEKLIST)"

△6 FULL PENETRATION WELD REQUIRED.

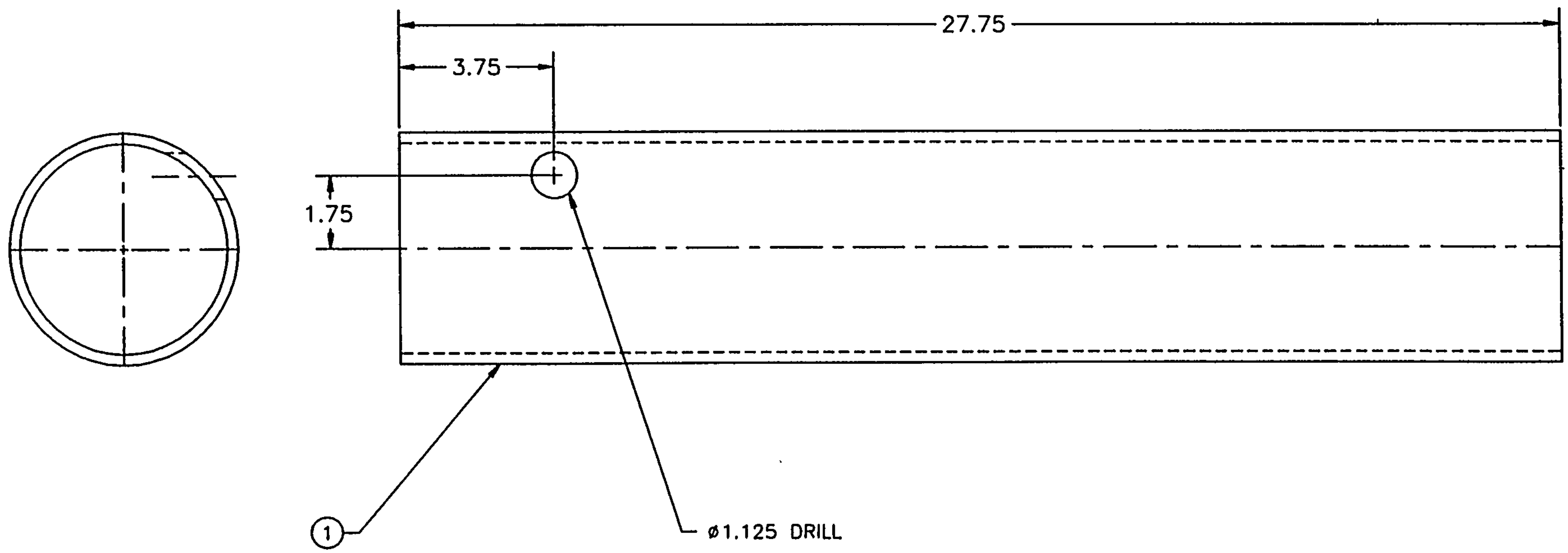
-2 QTY	-1 QTY	ITEM	PART NO	DESCRIPTION	MATERIAL SPEC
	1	6		PIPE COUPLING HALF, .5 - 18 NPT - 3000#	A182-F316L
	2	5		ROD, THREADED .75-10UNC x 1.5	A193 B7
	1	4	1138	COUPLING, MODIFIED, 1/2 NPT - 3000#	
	1	3	1077	PLATE, BASE, SAMPLER	
	1	2	1075	TUBE, MODIFIED	
	1	1		FLANGE, RF, S.O. 5" - 300#	A182-F316L

BODY, SAMPLER

UNLESS SPECIFIED ALL DIMENSIONS IN INCHES TOLERANCES: FRACTIONAL ± 1/16 3 PLC. DEC. ± .005 2 PLC. DEC. ± .030 1 PLC. DEC. ± .01 ANGULAR ± 2-1/2 DEGREES	DRAWN: DMB	DATE: 3-31-92	FUND NO: 4358
	CHECKED: GLS	DATE: 4-9-92	WORK REQ: W7
	MANAGER:	DATE:	REV: - SCALE: 3:8
	APP BY:	DATE:	SHEET 1 OF 1
	FINAL ASSY: 1076	NEXT ASSY: 1071	DWG. NO: 1074

1074

1003-C



-2 QTY	-1 QTY	ITEM	PART NO	DESCRIPTION	MATERIAL SPEC
		2			
	1	1		PIPE, WLD, 5" - SCH 40	A312-TP316L

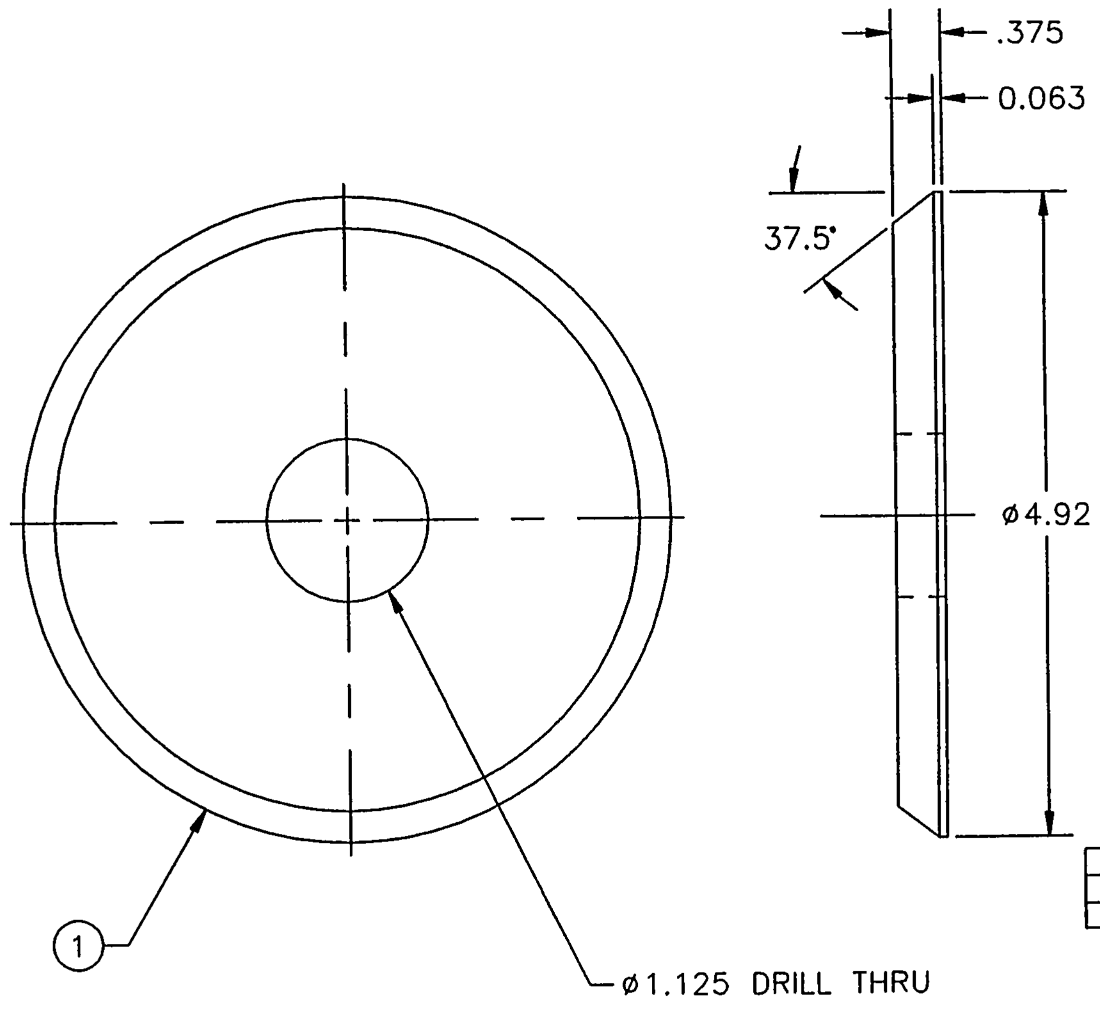
TUBE, MODIFIED

UNLESS SPECIFIED ALL DIMENSIONS IN INCHES
TOLERANCES:
FRACTIONAL ± 1/16
3 PLC. DEC. ± .005
2 PLC. DEC. ± .030
1 PLC. DEC. ± .01
ANGULAR ± 2-1/2 DEGREES

DRAWN: DMB	DATE: 3-30-92	FUND NO: 4358	
CHECKED: GLS	DATE: 4-9-92	WORK REQ: W7	
MANAGER:	DATE:	REV: -	SCALE: 1:2
APP BY:	DATE:	SHEET 1 OF 1	
FINAL ASSY: 1071	NEXT ASSY: 1074	DWG. NO: 1075	

1003-C

1075



		2			
	1	1		PLATE, .375 THICK	A240-316L
-2 QTY	-1 QTY	ITEM	PART NO	DESCRIPTION	MATERIAL SPEC

PLATE, BASE, SAMPLER

UNLESS SPECIFIED ALL DIMENSIONS IN INCHES TOLERANCES: FRACTIONAL ± 1/16 3 PLC. DEC. ± .005 2 PLC. DEC. ± .030 1 PLC. DEC. ± .1 ANGULAR ± 2-1/2 DEGREES	DRAWN: DMB	DATE: 3-30-92	FUND NO: 4358
	CHECKED: GLS	DATE: 4-9-92	WORK REQ: W7
	MANAGER:	DATE:	REV: - SCALE: 1:1
	APP BY:	DATE:	SHEET 1 OF 1
	FINAL ASSY: 1071	NEXT ASSY: 1074	DWG. NO: 1077

1077

1002-C