Interatom notice: This report has been reviewed by HEDL for gross errors; HEDL does not attest to the detailed technical accuracy of the contents herein.

From: Joachim Gilles, Department 0224, March 14, 1975

Project Designation SNR Project No. 0763-9426

Regarding FFTF Report: Pipe installation and welding technique at FFTF

Summary

The main sodium piping with a diameter of 16" or 28" is being installed at the FFTF construction site starting in December, 1974.

The supplier and authority demarcations discussed already in the FFTF report of February 12 of this year are: Combustion Engineering supplies the reactor vessel, guard vessel and adjoining pipes and uses the machine welding equipment "Dimetrics"; for the piping system of the primary and secondary loops the pipes manufactured by Rollmet at HUICO, Pasco, were delivered and prefabricated there, as far as compatible with the installation. "Astroarc" welding machines are used by Bechtel for the piping prefabrication in the weld laboratory as well as on site at the construction site.

Technical welding problems occurring during the course of the installation at the construction site and several during this time are described in the following. At present 6 weld seams in the reactor and 14 weld seams in the secondary loop are accepted.

The requirement exists to carry out as many welds as possible automatically, in order to produce sodium pipe welds of high technical quality and which are reproducible. The welding equipment is discribed in the following.

It should also be self-evident for SNR that a very exact pre-planning and preparation as well as detailed chicking of the welds takes place, as for the FFTF project.

Contents:

1. Extent of the welding

Bechtel Company has estimated that about 26,000 welds on small piping (carbon and stainless steel pipes 2" and smaller) as well as Ca.8000 welds on pipes larger than 2" are to be carried out at the installation. For the main stainless steel sodium piping principally considered in the report there are to be

welded on site for each loop all together: (not including 6 carbon steel Fluid Head welds on the penetration)

7 welds on the reactor nozzles
30 welds in the primary system as well as
70 welds in the secondary system

At the end of last year, about 15 automatic welding heads and 7 power supplies (for CE and Bechtel together) were on hand for the handling of this work. Included in that is the requirement for the training of the welding personnel not only in the weld laboratory outside the construction site but also training at the construction site and spare units. The space required for the installation of the welding equipment amounts to 8" (radial) and 12" (axial) for the Astroarc equipment as well as 4" for the Dimetrics machine. Adapter constructions were developed for the fitting of the welding heads at the elbow.

The qualifications of this welding equipment and the limiting conditions for the welding has already taken place in the previous year. This included weld samples of the 304 piping (16" diameter) and of the 316 material (28" diameter), non-destructive testing of the weld samples as well as destructive testing also for the qualification corresponding to the RDT Standard F 6-5T. The welders for the construction site were trained in the weld laboratory in Richland also and qualified according to the existing specifications. Although as much as possible will be machine welded, the manual welding method was also qualified as a back-up solution.

2. Reactor

The position and sequence of the 7 welds carried out by Combustion Engineering in the reactor cavity on each loop of the reactor vessel and guard vessel are to be seen on the following three pages.

Before the installation of the reactor vessel, the attached (connected) piping was suspended temporarily inside the reactor cavity.

In order to make possible the on-site assembly of the reactor vessel, an extension piece (called a Dutchman) of 316 H has been introduced between the vessel outlet connectors and the first prefabricated piping segment of 316 H. For the same reason two extension pieces (1 Dutchman and 1 extension piece) are necessary in the region of the reactor inlet. In the 7 welds we are dealing with 6 machines as well as 1 manual weld (No. 6 at reactor outlet) which are divided into 4 i.d. and 30.d. joints.

The welding in the region of the reactor inlet began in February, 1975. Before the acceptance of the welds not only the Dutchman, but also the extension piece were brought on-site in their final shape and then adjusted for the welding preparation. The first two i.d. welds on the reactor inlet were completed by the middle of March with the help of the Dimetrics welding equipment. The

positioning of the reactor inlet piping (16") is labeled with 30°, 150°, 270° and the outlet piping o, 120°, 240° at the reactor circumference.

Access to the reactor cavity is allowed only to the personnel working there, the cleanliness is maintained by a tent above the cavity as well as by wearing bunny suits, furthermore, random samples are undertaken by swab tests which also had been undertaken during the installation of the reactor vessel and guard vessel. The inside of the piping is purged with argon, the extension pieces at the reactor nozzles are reinforced until after the welding by inside supports.

According to the project specifications used, the permitted tolerances with 3/8" wall thickness of the main piping reads:

> 12.5% of the wall thickness and
> 1/32" max. deviation from the nominal radius at the weld

From this it follows that with much smaller wall thickness a further layer is deposited and polished.

3. Piping

In the prefabrication by HUICO Company in Pasco, the maximum possible pipe lengths (up to 42 ft.) were manufactured in the TIG welding process and to be sure not only in a process in which the piping rotated, but also with Astroarc welding machines, in which the welding head is led around the piping.

After Bechtel Co. had finished the architectural work including production of the sodium catch pans in the primary and secondary system, the spools were called off by HUICO and delivered to the construction site (see enclosed pictures, attachment.)

Corresponding tc the existing cleanliness, installation and inspection requirements, attention should be paid that:

-- the weld prep at the weld seams is protected by caps; these serve at the same time for the airtight closing of the stainless steel pipes;

-- that a wrapping with an allowable plastic material follows;

-- that the ends of the pipes were provided with nylon rope mesh for protection during rigging into position, and during transportation and storage sufficient supports are provided for.

-- In the first weeks of the welding attention must be paid that the caps on the piping can be actually opened only if no further work was carried out in the area of the piping installation which can influence the cleanliness.

-- Since in various regions of the plant at first concrete work was still being done, attention also must be paid that in the heat transport loop the humidity (moisture) remains within the allowable limits which was guaranteed by additional instrumentation at the beginning of the welding.

-- For the protection of the personnel working in the HTS loops instruments for air inspection were installed, e.g. to avoid having the argon purge gas unintentionally escape (leak) at the bottom of the cells. The cleanliness stipulation requires furthermore the wearing of bunny suits and the prohibition of touching the stainless piping with the hand.

-- During the welding processes in the cells themselves, only the welding and supervisory personnel may stay in the cell. Attention is to be paid directly that during the welding process no jolting machines and motor bulldozers, graders, (planers?) may operate in the vicinity of the building.

After delivery of the piping at the construction site, the unloading follows in the corresponding positions and installation in temporary pipe hangers (see attachment 3 for piping location).

The installation of the piping follows in such a way, that each was installed according to the availability of the loop components and clearance of the fixed points of the system favored in the area, in which no larger components are brought in later. In the HTS cells the connections to the IHX and pumps in the corresponding guard vessel vere tentatively suspended. Accordingly most of the primary and secondary piping was brought in and positioned in temporary hangers. The 28" and 16" bellows equipment in combination with the valve cell penetration are finished at the last so that piping segments in the region of the HTS cell plugs can be installed first after these components.

In the case of the piping which is invariably made of stainless steel, material 316 H is used in the hot leg and 304 H is used in the cold leg (H indicates guaranteed carbon content between 0.04 and 0.08%). Not only the 16" but also the 28" diameter piping have a wall thickness of 0.375".

The fit-up of the piping before the welding takes place in such a way that an insert of 1/8" thickness is tack welded (at one) on a side and the second side of the piping is adjusted again. The insert material as well as the electrode material also for 304/304 connections is material with 16% Cr, 8% Ni, 2% Mo(ER 16-8-2, Kellog, preventing S ferrite formation). The clearance of two weld edges including the measurement of 1/8" for the ensert amounts to a maximum of 0.15".

The welding conditions differ according to whether a weld is corried out by pipe axis proceeding vertically (2 G position) or horizontally (S G position).

On several piping pieces a trim length of about 3" was considered, so that the adjustment in reference to the building is possible. The tolerance of the piping to the final building position amounts to 3/8". The piping should have during operation an average gradient of 1/8" 1 ft. corresponding to about 1%.

The welding of the piping began in December, 1974, in the region of the secondary sodium pumps. Up to the time of this report 14 welds at the construction site - without exception in the three secondary loops - had been accepted by the independent AI.

It can be concluded from "Installation Procedure for large HTS - Piping within the HTS Cells (Component Installation Inspection Procedure No. 5003)" how many requirements for the installation have to be met and which of various kinds of checks during the course of the installation are to be carried out (attachment 4). In the case of piping designations in this CIIP and also on diagrams, GCA signifies the cold leg as well as GEA the hot leg.

4. Problems with the welds

A number of technical and administrative problems accompanied the first phase of the welding of large stainless pipes, both during the prefabrication and also at the construction site. Thanks to adequate experience in the weld laboratory and also thanks to detailed welding requirements accepted by all, all questions were solved until now. No weld has been rejected at the plant yet.

-- It was attempted to fit the data from the welding laboratory and in the qualification of the equipment and welders as exactly as possible with the on-site conditions. This was realized in large measure. However, the problem occurred for management that several welders, qualified at cost to the project, suddenly accepted other jobs and are not available for two shift operation at FFTF. On the basis of independent union systems it can thus happen here that high development costs arise for a "first of its kind" plant like FFTF, in order to qualify adequate personnel for welding of carbon and stainless steel pipes in manual or machine welding.

-- After fit-up of the first 28" pipe at the secondary pump suction it was determined that the attached pipe elbow in reference to the building dimensions was misplaced by about 1.5" horizontally. After twisting the pump tank about 24 angle minutes (0.5") an exact orientation was possible.

-- Before welding the Fluid Heads in the cold leg of the secondary loop at the containment penetrations, a new weld prep must machine the carbon steel connectors, since the center lines of the containment penetrations and the 16" piping in all 3 loops are misplaced to the side about 1" since the completion of the concrete work).

--The problems occurring in the welding of the hot leg Fluid Heads and bellow assembly out of Material 316 (cracking) are avoided by preheating the material at 250° F and addition of 5% hydrogen in the argon cover gas.

-- The question of weld shrinkage will be referred to in the last chapter of this report.

5. Welding Technique

Several facts about the TIG welding technique for FFTF are summarized:

-- Essential parameters for a weld are diameter, thickness, root face thinkness, max. allowed misalignment, weld seam position.

-- A tpyical designation of a weld seam, whose specifications are in the enclosed Bechtel Welding Schedule (Astro-Arc E-200 P/AM II, attachment 5):

16-5G-K-3A

i.e. 16" pipe diameter (0.375" weld)
5G weld position, pipe axis horizontal
(in comparison to 2G pipe axis vertical),
K Kellog insert (form 1/8" x 5/32"),
3 Code number for the maximum allowed misalignment according to the weld seam equipment.
A Code number for material 304 H (ASME SA - 376) in distinction to B for 316H

-- The weld prep with phase only takes place with piping larger than 2" diameter because of the larger weld-shrinkage.

--The number of weld passes in addition to 1 root pass is:

28" and 16", 5 G position 5
28" and 16", 2 G position: 14

-- The time to do the root pass with the Astroarc weld head with a 28" diameter in 5G position amounted to 40 minutes, the total welding process about 8-10 hours because of the cooling time between the individual passes. In addition there are testing times for 2 dye penetrant tests (after the root pass and after the last pass) as well as the final X-ray examination.

-- The welding of the root pass of a 16" joint took about 22 minutes.

-- The pulsation of the welding in the case of the root pass takes place in this way, that for example a current of 130A exists for 0.3 sec and fluctuates in order that a current of 70A exists for 0.2 sec. In the case of the fill paths the electrode only oscillates with an amplitude between 2 and 5 sec. with welds in the 5 G position.

-- The power supply of the Astroarc works at 440V, transformation takes place to a welding-arc voltage between 8 and 20V each time according to the welding parameter. For the welding in the FFTF secondary system, a power supply is

always wet up in the secondary pump towers, the welding heads can work a maximum of 200 feet distant from it. The operating characteristics of the power supply can also be controlled directly at the welding location.

-- In the case of vertical welding positions, the welding takes place counter clockwise and begins, in the case of the root pass, in the 2 0'clock position with all following passes between 10 and 2 o'clock positions.

-- The minimum room temperature around the Na piping is 60°F, the maximum interpass temperature is 350°F.

-- Outside of the different required space mentioned previously for the weld heads, the equipment of the products "Dimetries" and "Astroarc" is essentially the same.

6. Quality Control

The stainless welds must be X-rayed 100%. Normally this takes place with film, however, with the exception - in case it must be photographed through more than 2 walls - in an o.d. weld it takes place with an iridium-182 source. This is normally not provided for according to the ASME, since the source radiates in point form and overexposes the film and thus aggravates the fault perception.

Likewise in the case of the dye penetrant test required at each weld there is a discussion of whether the medium and also the developer should be applied in place of the normally used brushing, in order that the effect of these chemicals remains limited locally. In hard to reach areas, the danger could exist besides, that chemical residues could not be completel' removed after the welding process.

For the sealing of the piping from within during the welding process and the necessary purging process, purge bags are introduced from within. The components normally held under cover gas atmosphere must be placed under cover gas again if it is not worked on the component for larger than 1 shift (cover gas flow rate 10 cubic feet 1 hour for all pipe diameters, 0_2 content less than 1%).

Bleach tests by Bechtel have proved that the plastic materials used for the covering and splicing tapes contain so little halogen that the cleanliness of the component surfaces required in RDT-F 5-1 of less than 5 ug/in^2 of chloride and fluoride is fulfilled. Saturated isporopyl alcohol is used to clean the stainless steel surfaces.

After completion of the first three 16" welds on the secondary sodium pump housing, a longer discussion about the acceptance of these welds was held on behalf of the quality position of HEDL and Bechtel as well as the AI, whether an acceptance of the seam could take place because of the center line shrinkage. This shrinkage produces a streak going through on the

X-ray film which could be declared a fault in the root pass. However, it was guaranteed in each case, by a second x-ray photograph from a non-perpendicular angle, that the welds are in order.

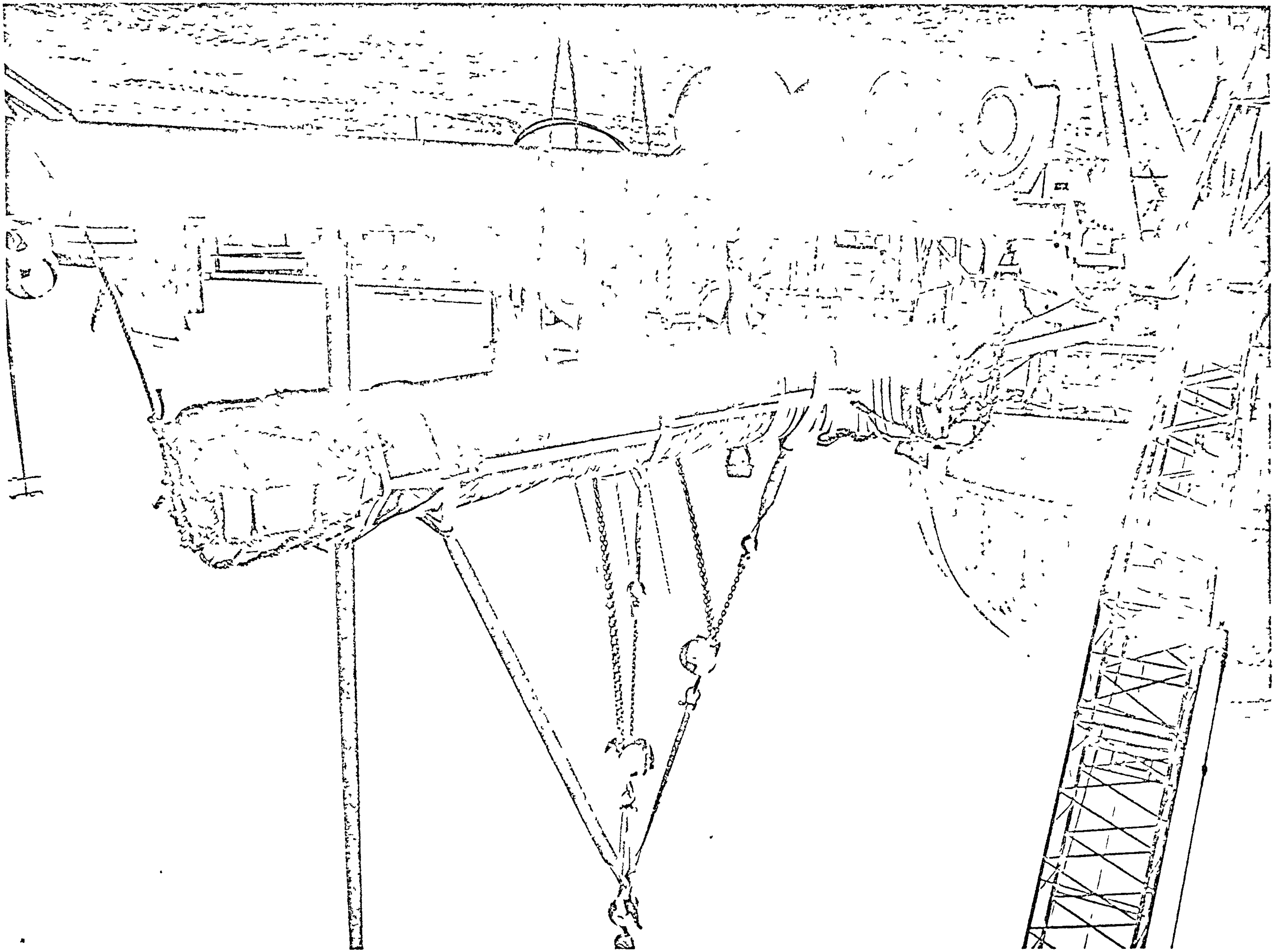
This question of the center line shrinkage was discussed before during the qualification work in the weld laboratory in 1974 but had not been decided. This also led to a inquiry at the ASME committee recently.

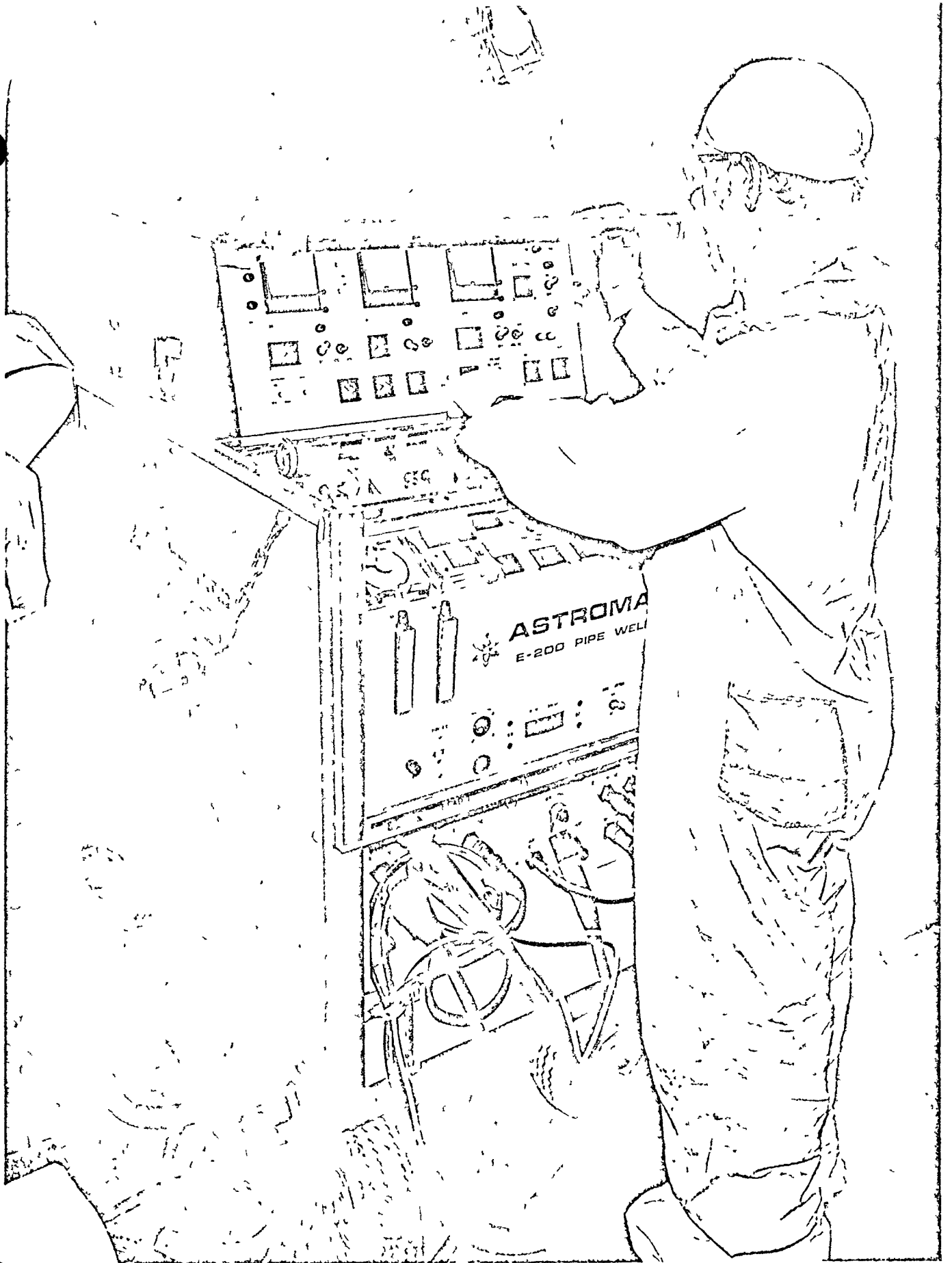
Work samples and destructive testing prove that in spite of the dimensional difference (0.007" in radius), no change of the mechanical welding properties was given. This effect of the shrinkage is minimalized in the CE welding on the reactor only by the use of a cover gas with 95% argon and 5% H_2.

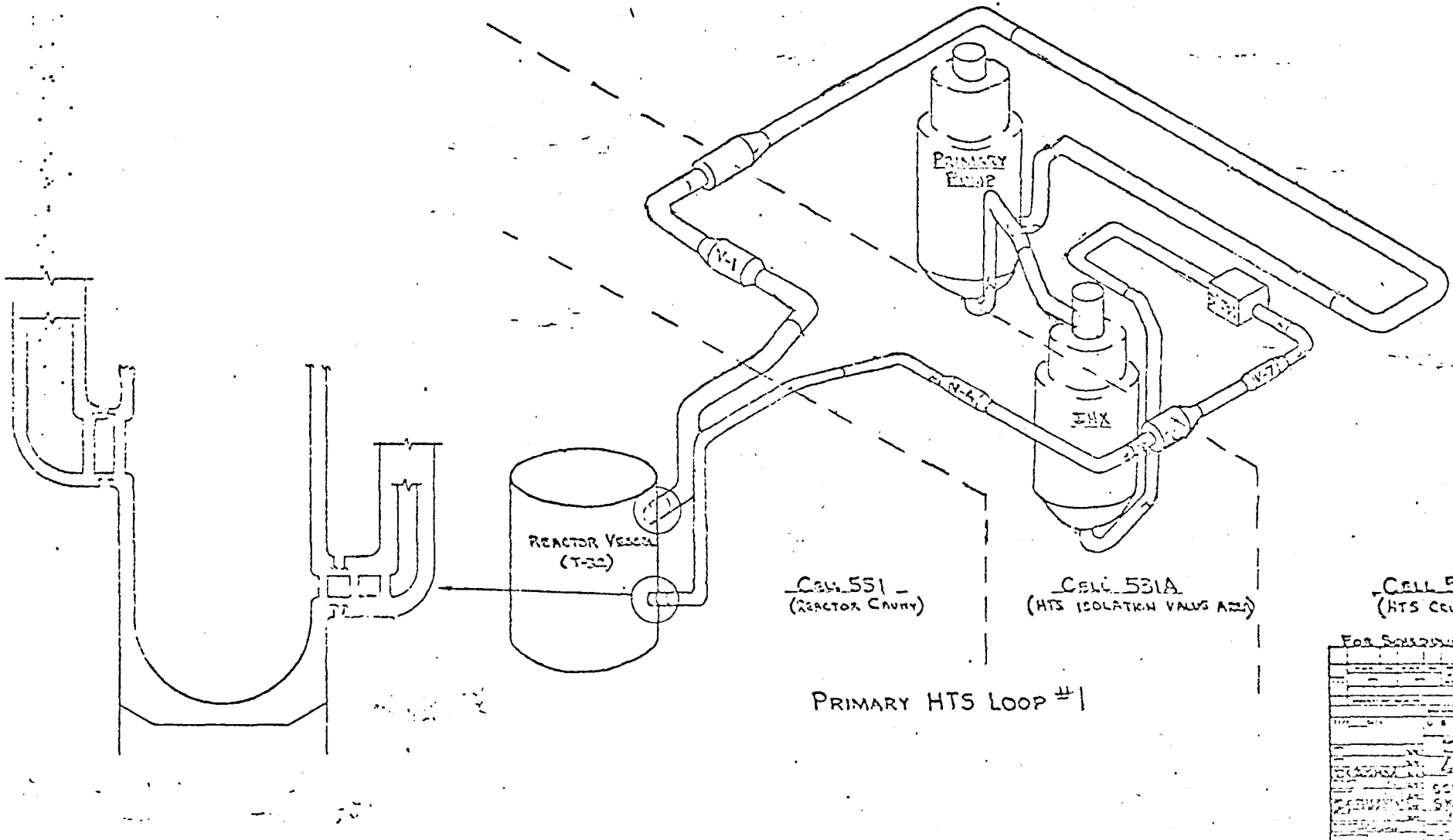
Another effect, the diametral shrinkage discernible from the outside after shrinkage of 16" and 28" piping, is a well-known fact. It is tested by measurement at four places on the diameter before and after welding, that the permitted dimension of 1.5% of the diameter is not exceeded.

Carbon steel welds can be corried out manually (as sometimes on the building penetrations) or also by machine (as is already done with several 4" pipes in the auxiliary system.) The acceptance of these seams (joints) follows according to the method of the magnetic particles.

Attachment 2




ASTROMA
E-200 PIPE WELI



PRIMARY HTS LOOP #1

Attachment 3

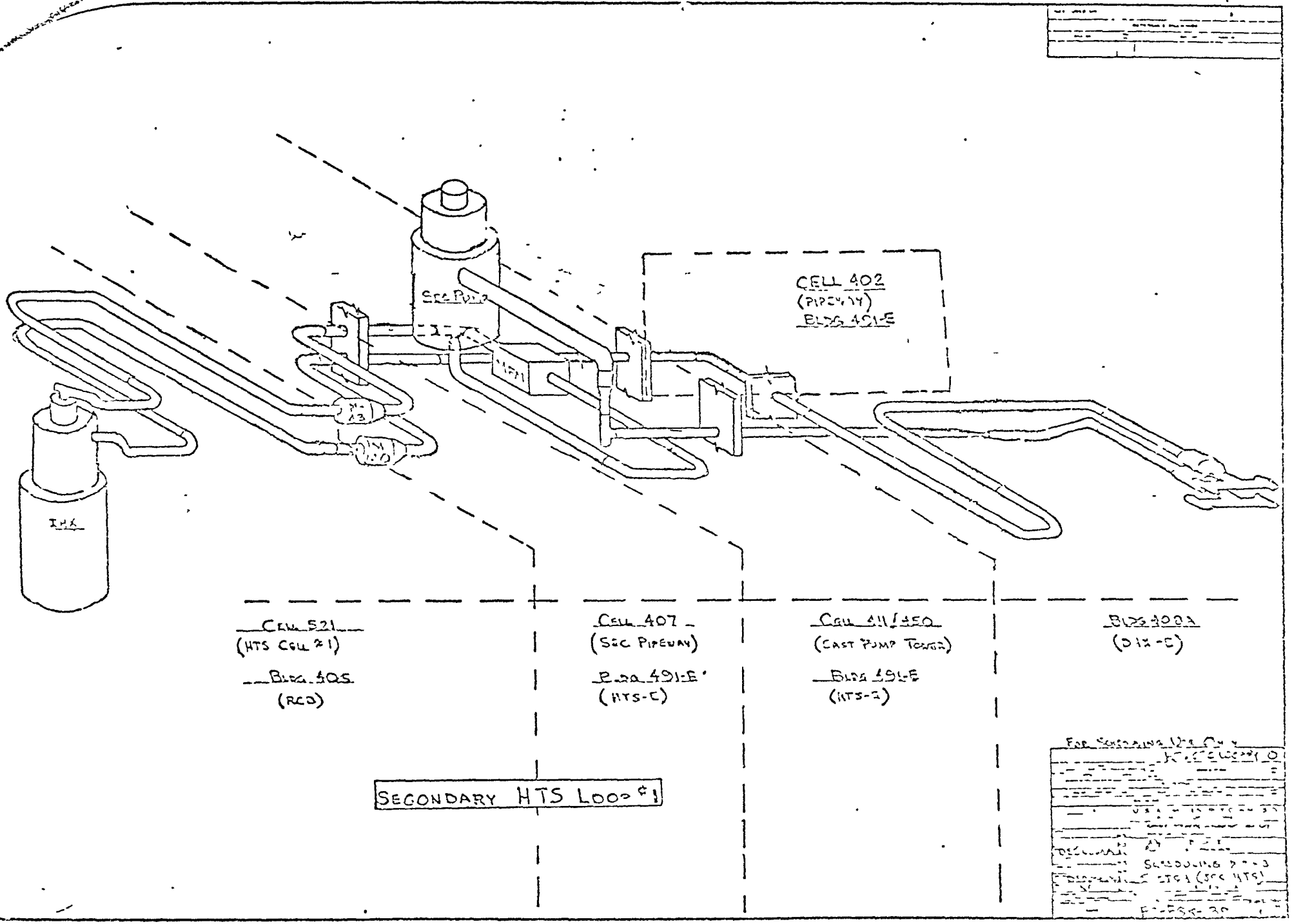
FOR SCHEDULING USE ONLY

HTS PRIM LP #1

SCHEDULING PIPIN

SKETCH (PRIM HT

HTS-ESM-132


CELL 402
(PIPEWAY)
BLDG 491-E
SEC PUMP
IHX
CELL 521
(HTS CELL #1)
BLDG 405
(RCO)
CELL 407
(SEC PIPEWAY)
BLDG 491-E
(HTS-C)
CELL 411/450
(CAST PUMP TOWER)
BLDG 491-E
(HTS-2)
BLDG 800A
(D1%-C)
SECONDARY HTS LOOP #1

attachment 4

INSTALLATION PROCEDURE

for

LARGE HTS PIPING WITHIN THE HTS CELL (s)

COMPONENT INSTALLATION INSPECTION PROCEDURE

NO. 5003

G P Martin — Field Construction Approval — 10-15-74 Date

10-17-74 REW 10/16/74 — W A Dreisbach — Bechtel QA/QC Approval — 10-17-74 Date

A D Jarvis — HEDL APPROVAL — 10-30-74 Date

R E Kosky — ARD CONCURRENCE — 11/11/74 Date

REFERENCE _____

"This is an approved AEC FFTF Project Office Procedure

BECHTEL	FFTF PROJECT NO. 8776	REV' 3	DATE 10-14-74
		PAGE	OF

Weld Schedule No. 16/5G/K-3A PQR: 350 Attachment

Joint Type ASA 37 1/2 degree Land Thickness 1/32" to 1/16" Misalignment 0-1/32" M

Base Material: Type 304-H Pipe Diameter 16 inch Wall Thickness 0.375" Nomi

Filler Wire: Type ER 308 Diameter 0.045"

Insert Material: Type ER 308 Shape Kellogg Size 1/8" X 5/32"

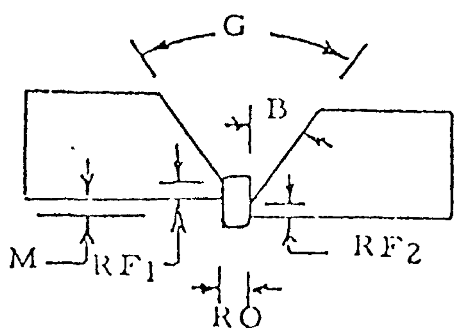
Welding Electrode: Type 2% Thoriated Diameter 1/8" Shape 30 degree Pointe

Shielding Gas: Torch Argon CFH 20 Cup 7 , Backup Argon CFH 10

Welding Position 5G - Horizontal Fixed Deposit Sequence As per attached sketch

E-200P Programmer Settings	Weld Pass											
	Root	1	2	3	4	5	6	7	8	9	10	1
Arc Voltage - DC	9.3	3.7	9.0	9.0	9.0	9.0						
Wire Feed Rate, IPM	00	20	25	30	30	15						
Wire Delay Time, Seconds	00	0.5	0.5	0.5	0.5	0.5						
Wire Upslope Time, Seconds	00	9.9	9.9	9.9	9.9	9.9						
Wire Decay Time, Seconds	00	00	00	00	00	00						
Carriage Rate Dial	1.6	1.6	1.6	1.6	1.6	1.6						
Carriage Rate Actual, IPM	2 1/8	2 1/8	2 1/8	2 1/8	2 1/8	2 1/8						
Carriage Delay Time, Seconds	3.0	0.1	0.1	0.1	0.1	0.1						
Oscillator, CPM	00	70	70	70	70	70						
Dwell Left Time, Seconds	00	00	00	00	00	0.1						
Dwell Right Time, Seconds	00	00	00	00	00	0.1						
Weld Current, Amps	120	90	130	135	135	135						
Taper Current, Amps	120	90	130	135	135	135						
Pulse High Time, Seconds	0.3	00	00	00	00	00						
Taper Current Time, Seconds	00	00	00	00	00	00						
Pulse Low, Amps	70	00	00	00	00	00						
Pulse Low Time, Seconds	0.2	00	00	00	00	00						
Finish Slope Time, Seconds	9.9	9.9	9.9	9.9	9.9	9.9						
Pre-Purge Time, Seconds	5	5	5	5	5	5						
Post-Purge Time, Seconds	10	10	10	10	10	10						
Arc Voltage Switch	ON	ON	ON	ON	ON	ON						
Wire Feed Switch	OFF	ON	ON	ON	ON	ON						
Carriage Switch	ON	ON	ON	ON	ON	ON						
Oscillator Switch	OFF	ON	ON	ON	ON	ON						
Pulse Switch	ON	OFF	OFF	OFF	OFF	OFF						
Arc Start Switch	ON	ON	ON	ON	ON	ON						
AVC Lift Switch	OFF	OFF	OFF	OFF	OFF	OFF						
Pulse Low Sense Switch	OFF	OFF	OFF	OFF	OFF	OFF						

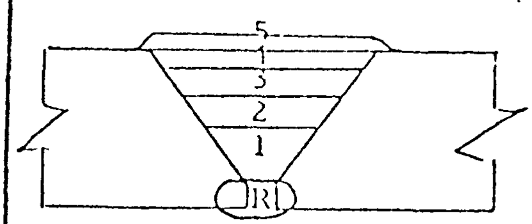
M-II Weld Head Settings	Root	1	2	3	4	5	6	7	8	9	10
Oscillator Amplitude	0	2	2 1/2	3	4	4 1/2	(Approximate Only)				
* Electrode Extension, Inches	(1/8" - 3/8")										
* Electrode to Pipe, Inches	(1/32" - 1/16")										
Electrode to Wire, Inches	(1/32" - 1/16")						(Approximate Only)				
Axial Offset Angle	0°	0°	0°	0°	0°	0°					



Dim.	Nominal	Maximum	Minimum
B	37-1/2°	37-1/2°	35°
G	75°	75°	70°
M	N/A	0.031	N/A
RF-1	0.031	0.041	0.031
RF-2	0.063	0.063	0.053
RO	1/8"	5/32"	1/8"

ALLOWABLE JOINT TOLERANCES

B) WELD DEPOSITION SEQUENCE

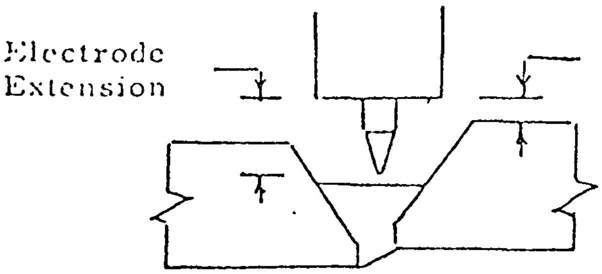


NOTE: Permissible variations in pipe wall thickness and weld joint dimensions may occur and require an additional weld pass to that depicted in this section. An additional pass, if required, shall be deposited using the same programmed setting for weld Pass 5 of this schedule.

C) SPECIAL INSTRUCTIONS

1) Electrode Extension

The electrode extension shall be such that the maximum clearance between the shielding gas cup and the highest point on the pipe surface does not exceed 3/16 inch.



2) Electrode to Pipe Distance

This distance shall apply to the electrode to pipe spacing prior to arc initiation.

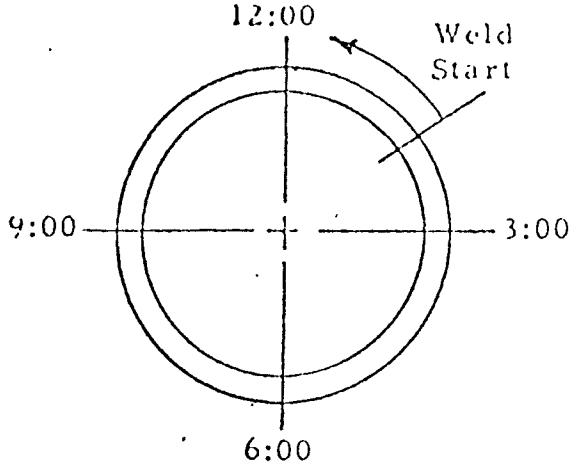
Continued . .

NO	DATE	REVISION	BY	CHK'D

Astro-Arc E-200P/AM-11
Welding Schedule 16-5G-K-3A

C) SPECIAL INSTRUCTIONS (Continued)

3) Weld Start Location and Welding Direction



The weld start location for the root pass shall be at the 2:00 (O'Clock) position, looking from the torch side of the AM-11 assembly. Subsequent passes shall be staggered between 10:00 and 2:00 clock locations. The welding direction shall be counter-clockwise, facing the torch side of the AM-11 assembly.

4) Arc Length

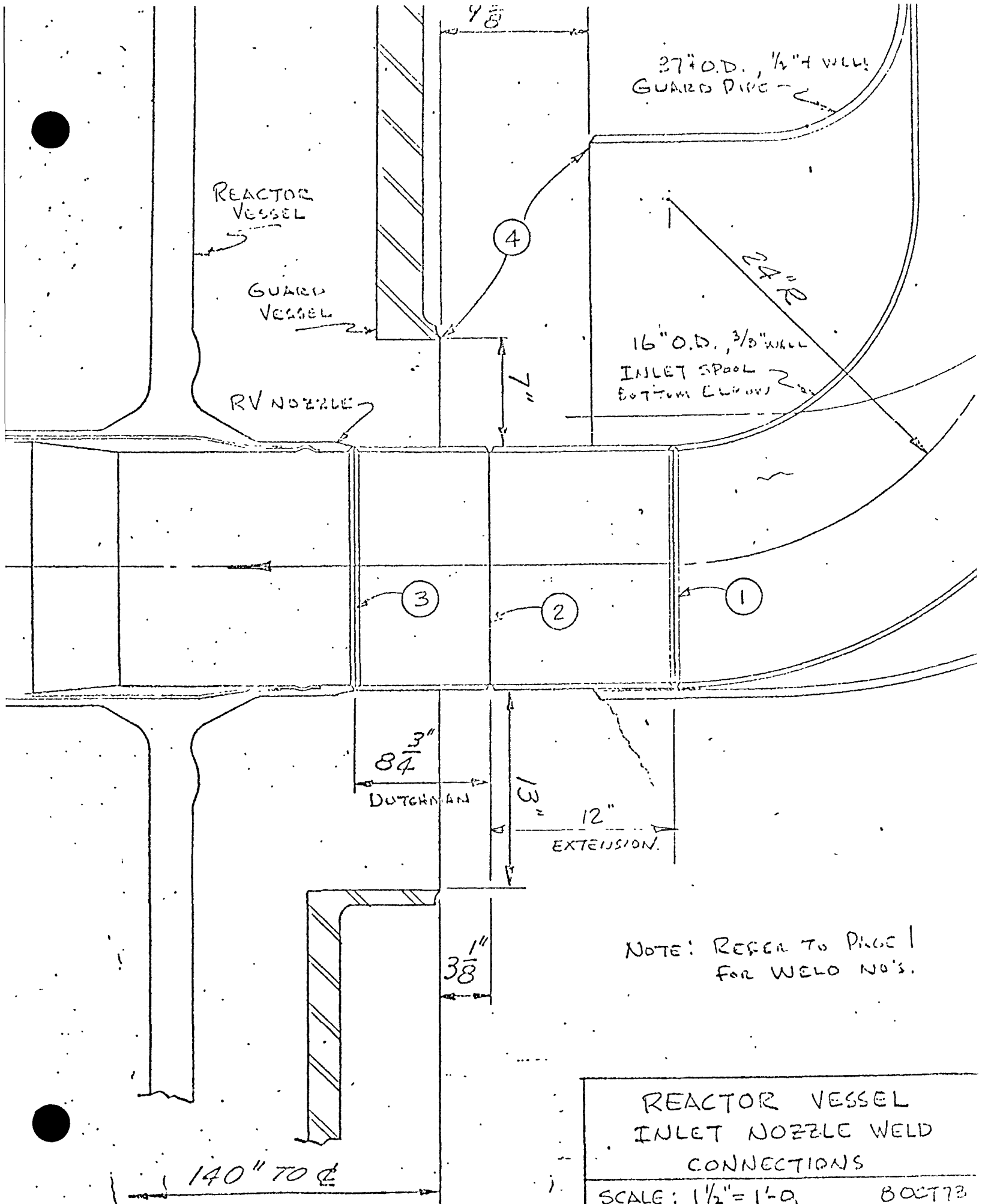
The arc length for the last fill pass and cap pass shall be held close enough to prevent any undercutting. Required AVC adjustments shall not exceed +10 per cent or -5 per cent of that value used for procedure qualification and shall be made in accordance with Table 3 of this specification.

NO	DATE	REVISIONS	BY	CHKD	ENGR	APPD
SCALE		DESIGNED	DRAWN			
ORIGIN		Astro-Arc E-200P/AM-11 Welding Schedule 16-5G-K-3A			JOB NO DRAWING NO.	

SUMMARY OF PIPE WELDMENTS
REACTOR VESSEL INLET AND OUTLET

REFER TO PAGES 2 & 3		WELD PREP		PERFORM BY		ORDER OF
WELD NO.	DESCRIPTION	I.D.	O.D.	MANUAL	MACHINE(1)	WELDING
1	(Inlet, 16" dia.) 12" Extension to bottom elbow	X (J-Groove)			X	1
2	(Inlet, 16" dia.) Closure weld		X (J-Groove)		X	3
3	(Inlet, 16" dia.) Dutchman to RV nozzle	X (J-Groove)			X	2
4	(Inlet 37" dia.) Guard Pipe to GV		X (V-Groove)		X	4
5	(Outlet, 28" dia.) Dutchman to RV nozzle	X (J-Groove)			X	1
6	(Outlet, 28" dia.) Dutchman to elbow	X (J-Groove)		X	X	2
7	(Outlet 43" dia.) Guard Pipe to GV		X (V-Groove)		X	3

NOTES: (1) Dimetrics Pipe Welding System

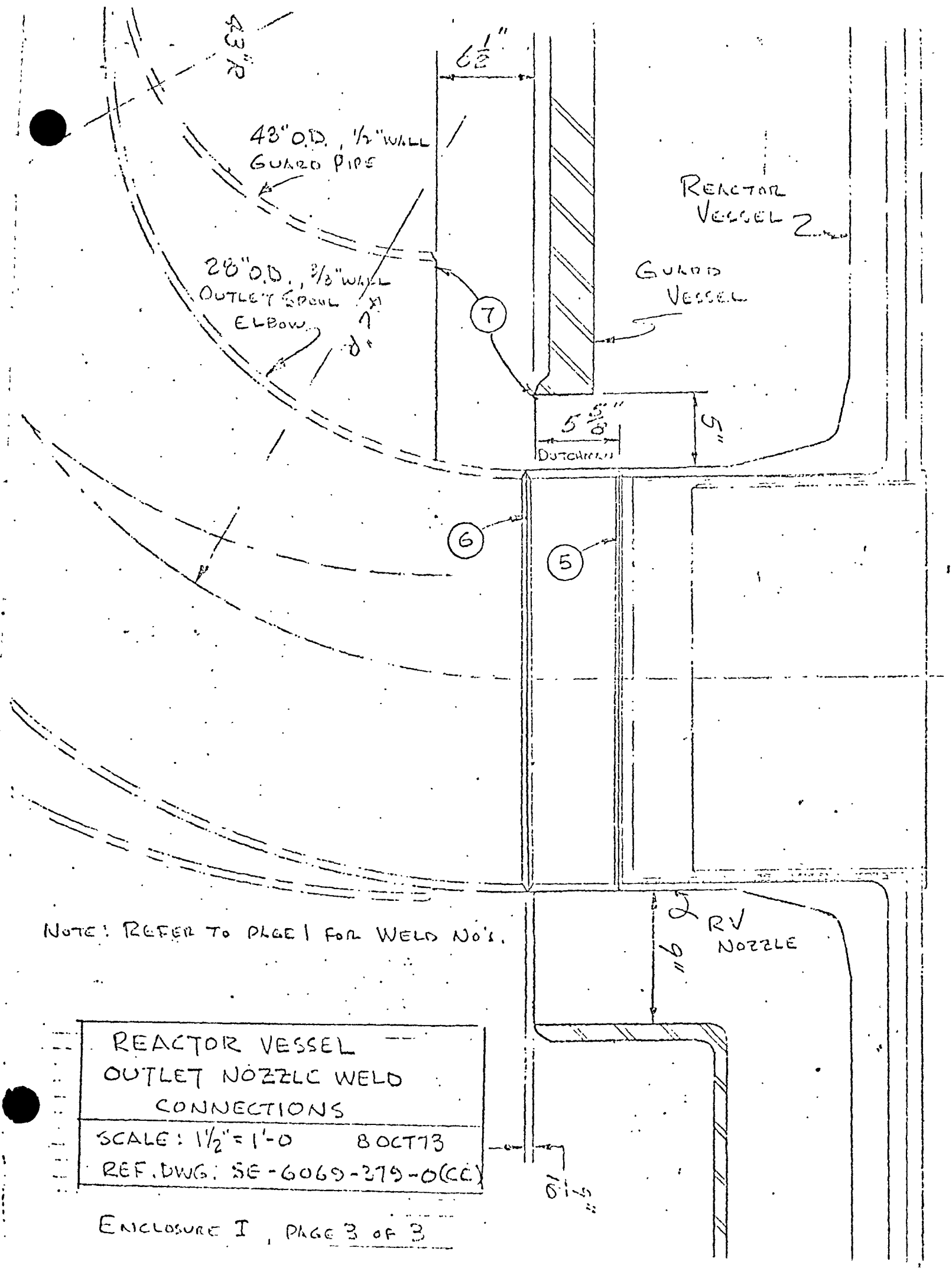


NOTE: REFER TO PAGE 1 FOR WELD NO'S.

REACTOR VESSEL INLET NOZZLE WELD CONNECTIONS

SCALE: 1 1/2" = 1'-0 BOCT73

REF. DWG SE-6069-380-0 (C



NOTE: REFER TO PAGE 1 FOR WELD NO's.

REACTOR VESSEL OUTLET NOZZLE WELD CONNECTIONS
SCALE: 1½" = 1'-0 8 OCT 73
REF. DWG: SE-6069-379-0(CE)