



Exploration & Production

GENERAL SPECIFICATION

PIPELINES - RISERS

GS PLR 405

**Design and installation of hot tapings
on subsea gas pipelines**

01	10/03	Change of Group name and logo
00	02/01	First issue
Rev.	Date	Notes



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1. Scope

This specification covers the recommended practices and minimum requirements to perform a hot tap operation onto a subsea gas carrier pipeline.

2. Reference documents

The reference documents listed below form an integral part of this General Specification. Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and supplements, is the latest revision published at the EFFECTIVE DATE of the CONTRACT.

Where national regulations exist, their provisions and those of the standards and codes to which they refer shall apply, supplementing or amending the provisions of this document.

If there are no national regulations covering all or part of the subject of this document, the reference documents shall be strictly applied, as supplemented by the provisions of this document.

Only the main reference documents are mentioned. Compliance with all secondary reference documents dealing with the subject of this document must be done.

Unless otherwise indicated in the detailed contractual conditions, all the reference documents to be used, as well as their supplements shall be the latest editions.

Standards

Reference	Title
BS 8010 part 3, 1993	Pipeline subsea: design, construction and installation
BS 4515	Welding of Steel Pipeline on land and Offshore
DIN 17102	Specification for Material

Professional Documents

Reference	Title
DNV	Rules for Planning and Execution of Marine Operations
EEMUA 185	Guide for Hot Tapping on Piping and Other Equipment
API 5L	(American Petroleum Institute) Specification for Line Pipe
API RP 2201	Procedure for Welding or Hot Tapping on Equipment in Service
API 1104	

Regulations

Reference	Title
	UK Pipeline Safety Regulations

Codes

Reference	Title
ANSI B 16.34	Valves - Flanged and Butt welding End
ASME/ANSI B 31.8	Gas Transmission and Distribution Piping Systems
ASME B 31.3	Refinery piping

Other documents

Reference	Title
Not applicable	

Total General Specifications

Reference	Title
GS PVV 142	Valves
GS PLR 422	Hyperbaric welding of carbon steel pipeline to API 1104 (sour effluent)

3. Design

3.1 Branch connection design and arrangement

3.1.1 Design data

As a minimum, the following data are required in order to design the branch connection:

- Process data (Operating and design pressures and temperatures, nature of the fluid, Low Explosivity Level (LEL), etc.)
- Location of the hot tap
- Actual wall thickness of the pipe at the location of the hot tap
- Line pipe material designation and characteristics
- Mechanical data (nominal thickness, diameter, corrosion allowance, etc.)
- Information relative to the pipeline configuration (curve, free spanning, etc.) where residual laying stress could be expected.

3.1.2 Tie-in arrangement

The tie in welding arrangement shall be designed as shown on the figure 1 attached in Appendix 1.

3.1.3 General welding requirements

The general welding requirements listed hereafter shall be adhered to:

- Hot tap tee branch located at the 12 o'clock position
- The branch weld shall be a full penetration weld onto a buttering layer
- A fillet weld between the reinforcing saddle and the branch nipple
- Two longitudinal seam welds on the reinforcing saddle half shells shall incorporate backing strips
- Circumferential fillet welds shall not be provided at the reinforcing saddle extremities to seal the pipeline to sleeve annulus. This can however be performed using approved Retrowrap system impregnated with an Amojel gel type or equivalent anti corrosion product. The Retrowrap system or similar shall be applied in a dry environment to prevent bacterial and crevice corrosion taking place between pipeline and saddle. The sleeves shall be designed to be effective for the duration of the design life. Retrowrap installation guidelines and Amojel data sheets are in Appendix 2.

3.1.4 Wall thickness requirement

The branch pipe wall thickness shall be sufficient to ensure that the governing Pipeline Code allowable stress criterion are satisfied under the design loads. ASME stress intensification factors for in-plane out-of-plane bending shall be applied in the stress calculations.

3.2 Finite Element Analysis

A 3D Finite Element Analysis (FEA) of the as-designed hot tap connection shall be carried out to determine the test pressure required, prior to trepanning, to verify the integrity of the full penetration branch weld. The analysis shall verify that the pressure determined will not create over stress in the complete welded assembly or buckling of the mother pipeline wall.

The analysis shall also take into consideration the following parameters:

- Pressure in the line at the time of the offshore operation
- Components shape and dimensions
- Existing pipeline as built dimensions (ovulate, wall thickness, etc.)
- Pipeline/branch/saddle dimensional tolerances that affect the fit between the saddle and the pipeline/branch. If appropriate, the effect of injecting epoxy resin grout or similar into the annulus between the saddle and the pipeline/branch shall be determined
- Misalignment due to welding tolerances
- Welding procedures
- Mechanical characteristics of the welded components.

The FE model shall be validated by a hydrotest. During this test, calibrated strain gauges shall be located at appropriate locations on the trial piece in order to confirm the correlation between computer model and actual findings. Strain gauges shall be cycled to ensure they are calibrated.

The FE analysis of the hot tap branch shall be performed using an industry recognised software program such as ANSYS, ABAQUS or ALGOR.

3.3 Material and components selection

3.3.1 Branch nipple

The branch nipple material grade shall be the same as the pipeline's in order to minimise the size of the hyperbaric welds.

The branch butt to mother pipe shall be bevelled to allow full penetration weld onto the pipeline buttering layer.

3.3.2 Reinforcing Saddle

The design of the reinforcing saddle shall be in accordance with the "Replacement area method" for the reinforcement of welded branch connections given in the [ASME B 31.8](#) Code: Gas transmission and distribution piping systems.

When there is no requirement for resin injection, the reinforcing saddle shall be manufactured in order to minimise the gap/void between the pipeline and saddle to be no greater than 2 mm. An equivalent specification such as [DIN 17102](#) may be used.

The material grade shall be selected to offer the nearest characteristics and chemical composition possible to the pipeline material.

The branch reinforcement shall be full encirclement with a two or three piece saddle fabricated to meet the pipeline and branch installation tolerances at the selected tie-in location.

3.4 Hyperbaric welding

Hyperbaric welding shall be in accordance with Total specifications [GS PLR 422](#) or if not applicable, [BS 4515](#) shall be followed.

In case of Welding Heat Treatment (WHT) requirement and if heat losses are such that heating mattresses are not suitable, electromagnetic induction heating can be used on live pipelines to maintain the specified range of temperature required during the welding process.

3.5 Protection structure

The protection structure shall be designed to protect the subsea equipment from the following possible sources of damage:

- Dropped objects
- When the subsea facilities are located in a region where fishing activities are taking place, fishing gear impact load shall be considered. The fishing intensity and type shall be assessed and data collected from a recognised competent source. The impact and pullover energies shall then be assessed through a design activity.

The design of the protection structure shall comply with, as a minimum, Norsok, in particular to being overtrawlable, non-snaggable and prevent trawl boards entering the structure. However, impact and drag/pullover loads from fishing gear shall be taken into account in the design.

The design of the structure shall ensure that it is de-coupled from both the pipeline(s) and the pipework for the design life of the equipment.

For the purpose of installation, the protection structure shall be made in two sections, lower and upper.



The concept for the structure, if required, shall encompass the following:

- Protection of the hot tap tee, piping and valves against fishing gear interaction and dropped objects. Temporary piping such as pig launcher/receiver shall also be protected
- The lower section of the structure shall provide support and guidance for the installation and retrieval of the hot tap equipment
- The lower section of the structure shall provide support and guidance such as guide posts for the installation of the upper section.

The protection structure shall not be used to support the valves or piping.

The protection structure design shall be based on current codes and standards, industry practices and experience.

3.6 Failure Mode Effect Analysis

A Failure Mode Effect Analysis (FMEA) of the hot tap valve(s) shall be conducted by a third party and where applicable, adequate corrective action(s) taken to ensure that the valve(s) is/are fit for purpose.

4. Limitation for hot tap operation

4.1 Design limitation

Hot tapping shall not be performed where one or more of the following conditions is/are met:

- Wall thickness below 6 mm
- Post weld heat treatment performed at the construction stage
- Pipe or equipment internally coated, clad or lined
- If there is insufficient clearance from a field joint
- Radius of head or bend
- If the pipeline seam weld is located nearer than 50 mm from the buttering layer heat affected zone
- On a pipe joint where an anode is fitted.

4.2 Operational limitation

Hot tapping shall not be performed where one or more of the following conditions is/are met:

- Pipe or equipment containing gas with more than 35% of oxygen
- Pipe or equipment is under vacuum
- Pipe or equipment where slugging can occur during the hot tapping operation
- Upstream of rotating machine unless such equipment is protected by suitable screens and filters.

In addition, when an electromagnetic induction heating system is used to provide adequate welding temperature, its power input shall be limited to prevent over heating of the pipewall.

5. Hole size selection

Metrology of the hot tap valve(s) stack up and trepanning machine flange mating shall be carried out to confirm the trepanning tool diameter in order not to cut into the pipeline heat affected zone and provide adequate fluid passage after hot tapping.

The hole diameter shall allow as a minimum the fluid passage required by the contract unless specified otherwise.

The branch diameter shall be designed to accommodate the requirements and constraints of the branch/valve/hot tap machine stack up metrology and all other system assembly requirements/tolerances.

6. Hot tap valve(s)

For a pipeline pressure above 70 barg, a double Block and Bleed valve system (DBB) shall be implemented to perform the hot tapping operation. However, where operational constraints such as a valve stack up height might impinge on the hot tapping accuracy, an alternative valve may be employed, i.e. double effect piston ball valve with a cavity drain. In this instant, DBB will still be required on the permanent arrangement after the trepanning operation.

Below 70 barg, a single valve (ball valve) is sufficient.

The hot tap valve shall be metal-to-metal seated and manufactured according to Total specification [GS PVV 142](#).

For the use of a double piston effect bail valve, the cavity body bleeding valves shall be provided with soft seats.

7. Hot tap machine

Only machines manufactured by experienced CONTRACTORS with proven track record shall be used.

The maximum working pressure and temperature rating of the machine shall not be exceeded.

The hot tap machine shall be capable of operating within the range of pressures and flows encountered in the pipeline.

The hot tap machine selected for the work shall be rated as follows:

- Pipeline MAOP during trepanning operation
- 1.5 times pipeline MAOP in static mode.

The trepanning tool centre drill bit shall be fitted with the following coupon retaining devices as a minimum:

- For pipeline flow rate from 0 to 10 m/s: 3 sets wire retainers
- For pipeline flow rate from 10 to 60 m/s: 3 sets wire retainers + a mechanical coupon retaining device, Posilatch or similar.

8. Work preparation

8.1 General

Prior to any hot tap work, the following written documents shall be prepared as a minimum and Approved For Construction (AFC):

- Stack up metrology
- Step by step hot tapping procedure with appropriate sketches and drawings
- Piping branch design analysis
- Induction heating (if applicable) and welding procedures
- Safety instruction notes (for personnel and equipment)
- Isolation valve and branch hydrotest procedure
- Hot tapping machine flange connection leak test procedure
- Interface communication procedure with the pipeline operator
- Contingency procedures.

8.2 Choice of the hot tap location

The hot tap location must be selected with regard to the following criteria:

- Suitable soil conditions (for protection structure installation if required)
- Location where the pipeline is exposed, to minimise the requirements for soil excavation
- Selected joint to be identified (chemical composition known) to establish appropriate welding procedures
- Longitudinal profile with minimum pipeline slope
- The pipe joint where the hot tap is to be performed shall be preferably close to an anode joint
- The pipe joint where the hot tap is to be performed shall not contain a buckle arrestor.
- The pipe joint where the hot tap is to be performed shall be selected in order to have the lowest carbon equivalent possible
- The pipewall at tie-in location shall comply with the acceptance criteria set in paragraph 8.6
- The pipeline seam weld is located such that it will be at least 50 mm away from the buttering layer heat affected zone.

8.3 Onshore trials

A series of onshore trials shall be conducted to verify that the installation method are appropriate and in accordance with the detail engineering calculations. The conditions under which the onshore trials have to be conducted shall simulate the offshore environment such as:

- Remote operation – Pressures
- Heat dissipation
- Etc.

The CONTRACTOR shall prepare a list of works to be conducted onshore prior to the offshore phase among which the following list is to be considered as a minimum:

- Hyperbaric welding
- Concrete/weight coat removal
- Corrosion coating removal
- Pipe joint dimensional checks (ovulate, etc.)
- Pipewall Non Destructive Examination (NDE)
- Reinforcing saddle fit around a pipe joint
- Induction heating for hyperbaric welding with thermal simulator (if applicable)
- Integration of hot tap branch and valve(s) in the hyperbaric welding habitat, setting of the habitat over a pipe joint and welding of the branch nipple and hot tap valve
- Installation of a pipeline mock-up piece and habitat door sealing
- Fitting and welding of the branch assembly and hot tap valve(s) to pipeline mock-up piece inside the habitat
- NDE of welds
- Metrology of the welded assembly
- Removal of the habitat. The habitat shall be guided by a rigid frame until clear of the hot tap valve during recovery. The habitat shall be fitted with an inside camera to display the operation
- Hydrostatic test of the pressure containing hyperbaric weld(s)
- Hot tap branch FE analysis verification using strain gauges and witnessed by COMPANY representative. The result shall be conservative and correlation made with the FE model.
- Setting up of the trepanning machine on the hot tap valve(s) stack up and flanges mating metrology
- Leak test of the hot tapping system (branch + valve(s) + hot tap machine all assembled) at MAOP of pipeline for one hour holding period
- Trepanning sequences (including valve(s) operation)
- Integration of hot tap piping assembly within its protection structure lower section
- Assembly of the protection structure sections and components over the entire tee connection system and associated piping assembly

- ROV panel integration and manual and remote valve operation
- Filling of piping with gel to avoid sea water ingress in the pipeline (if required)
- Records of hot tap parameters (see 10.7.1).

8.4 Weight coating removal

The method of weight coat removal shall be proven safe for the pipeline and onshore tests carried out to COMPANY satisfaction to validate the intended procedure.

High pressure water jet and re-bars cutting pliers shall be the first method implemented to remove the pipeline weight coat.

The HP water jet gun shall be provided with automatic release handle.

If the above method is not found to be efficient, the use of a hydraulic diamond saw may be authorised by COMPANY to remove the pipeline weight coating. In this case, circumferential measurements are taken to assess the thickness of the weight coat.

Concrete cores using the appropriate drill bits shall be taken every 0.25 meters along the cutting line at the four cardinal clock positions. Penetration shall be restricted to 75% of the assessed weight coating thickness. The diamond saw shall be provided with a positive mechanical stopper to ensure the cutting depth is not exceeded due to vibration or the like.

8.5 Corrosion coating removal

Corrosion coating shall be removed using high pressure water jet with grit entrainment.

The HP water jet gun shall be provided with automatic release handle.

The pipeline surface shall be cleaned to SA 2 1/2 either side of the hot tap centre in order to accommodate the following:

- Provide good pipewall surface for Close Visual Inspection (CVI), Magnetic Particle Inspection (MPI) and Ultra-sonic Testing (UT)
- Provide a good sound surface for the installation of the reinforcing saddle
- Provide good sealing surface for the Retrowrap anti-corrosion system.

Note: During welding habitat and protection structure installation over the pipeline, the locations where the weight protective coating has been removed shall be protected using concrete mattress or the like. This protection shall be proven to be as efficient as the original pipeline weight/protective coating.

If the pipeline is not concrete coated, the temporary protection shall be designed to prevent damage such as dent to the pipewall over areas, which may come into contact with the habitat/structure.

8.6 Pipewall inspection and dimensional verifications

The tie in point area shall be examined using NDE methods as described hereafter:

- Close Visual Inspection (CVI)
- Magnetic Particle Inspection (MPI)
- Ultra-sonic Testing (UT).



A final NDE shall be carried out in the dry. UT shall be displayed on the installation vessel while being performed.

The pipewall at tie-in location shall comply with the following acceptance criteria:

- Out of roundness: $\pm 1\%$ of specified measured with the appropriate tools
- Dents: not permitted within 200 mm of branch weld area. Maximum of 6.00 mm and not to extend in any direction greater than $1/4$ of pipe OD
- Lamination: No lamination allowed
- Longitudinal seam weld: NDE as per Total specification **GS PLR 422** or **BS 4515**. No defect permitted ± 800 mm of hot tap centre (see figure 2 in appendix 2). Seam weld position shall be located 50 mm away from the nearest branch weld
- Wall thickness: within the pipeline corrosion allowance design limit.

8.7 Coupon marking

The theoretical centre of the coupon to be cut shall be marked using centre punch on the pipewall prior to weld the branch nipple. Starting from this point, the mother pipeline wall will be marked every 25 mm along both its axis and circumference in order to calculate the trepanning tool deflexion from centre once the coupon is recovered.

8.8 Hyperbaric welds NDE and hydrotest

Prior to perform the hot tap, the welds shall be inspected in accordance with Total specification **GS PLR 422** or **BS 4515**.

The branch to mother pipe weld shall be validated by a 24 hours hydrotest to a pressure defined by the Finite Element Analysis.

9. Contingency plan

The critical operations related to the hot tap operations shall have back up contingency plans in place and ready to be exercised. This contingency plan shall include but not be limited to the following operations:

- Upon completion of the hot tap and closure of the DBB or the double effect piston valve are still bypassing. The contingencies listed here below can be implemented:
 - Cycle the valve(s)
 - Cascade pressures
 - Depressurise the valve body cavity (for a single "double effect piston" valve)
 - Bleed the vent to surface. The maximum allowable bleeding rate shall be calculated in order to prevent any freezing effect in the bleeding line
 - MEG injection (if confirmed appropriate)
 - Inject sealant.

The contingencies are listed here above in suggested order of implementation. However, following assessment with the offshore COMPANY representative. This may be subject to change offshore.



- A bypass is allowing the gas to go through the seals on the boring bar of the hot tap machine
- Failure or any equipment
- Weather conditions degrading.

As a minimum, all the critical events listed in this chapter shall have contingencies prepared. These contingencies shall be developed and gathered in a contingency procedure for COMPANY approval prior to the offshore mobilisation.

10. Hot tap operation (offshore)

All procedures for offshore operation shall be approved by COMPANY prior to vessel mobilisation.

10.1 Metrology and confirmation of cutter size

A metrology procedure shall be produced and approved by COMPANY prior to offshore mobilisation. This procedure shall determine the maximum construction and assembly tolerances for the branch stack up and hot tap machine. The aim of this procedure is to determine the maximum cutter tool diameter to be used offshore and retrospectively, set the installation criteria to ensure that the minimum hole size required can be achieved. The cutter size to be employed shall be agreed by COMPANY prior to commencement of the hot tap operation.

10.2 Leak test of the hot tap machine in situ

The leak test at pipeline MAOP (Maximum Allowable Operating Pressure) of the hot tap machine and flanged connection shall be witnessed and approved by a COMPANY representative. No test shall be started before approval of the procedure by COMPANY is obtained. The leak test shall comprise a one hour holding period.

All equipment shall be checked and function tested onshore before mobilisation.

Prior to starting the offshore hot tapping operation, the equipment shall be function tested to the satisfaction of the offshore COMPANY representative.

10.3 Pressurisation of the branch

The test medium used to pressurise the branch before the trepanning operation shall be selected in order to be compatible with the downstream plant treatment facilities and approved by COMPANY.

The selection of the test medium shall also take into account the requirement for dryness when it is passed into the pipeline after the trepanning have been performed.

The test medium shall be mixed in appropriate quantity with an approved fluorescent seadye component in order to permit quick and clear identification of leak path.

The pressure in the branch when the boring bar is in position to cut shall be between 0 and 10 barg above that in the pipeline. With the boring bar moving towards the pipeline, the valve stack pressure should not exceed the pipeline MAOP or the pressure defined by the Finite Element Analysis.

10.4 Hot tap back up spread

A back up hot tapping spread shall be provided during all operations. This shall include but not limited to:

- A spare hot tapping machine with equivalent certification and rating as the primary one complete with hot tap adapter
- A spare cutter for each possible size of hole to be undertaken
- A spare pilot drill
- A spare electro-hydraulic power pack
- A spare set of control and power valves
- A spare set of umbilical, high pressure hoses and power cable
- 100% power redundancy
- A volume of consumable of the correct quantity and quality such as pressure packings, oil seals, Hydraulic and lube oil, gaskets, RTJ rings and fasteners, fittings/valves/hoses to suit the venting/pressure lines and the like.

10.5 Trepanning operation

No hot tapping shall be started before approval of the hot tapping procedure by COMPANY is obtained.

The boring bar translation before (approach of the cutter to the pipewall) or after (recovery of the coupon through the stack up) the trepanning operation can be performed using the machine motorised boring bar translation device with the exception of the following circumstances where the boring bar shall be translated manually:

- The passage with the cutter through a valve
- To clear the cutter from the pipewall after the cut
- When passing a flanged connection
- 10 cm before each end course or an interference (e.g. Tee branch).

Before each trepanning operation, the machine cutter shall be carefully inspected.

The operation shall be witnessed by a COMPANY representative.

10.6 Hot tap valve(s) leakage assessment

Upon completion of the hot tap operation and prior to the removal of the hot tap machine cutter with the coupon in retracted position, the sealing of the isolation valve(s) must be assessed through a vent line located on the Hot Tap Machine (HTM) adapter void.

If the sealing is outwith the valves specification, a contingency measure described in paragraph 9 shall be undertaken with the agreement of the COMPANY offshore representative.

If the sealing is proven satisfactory, the void of the hot tap machine adapter shall be depressurised to ambient.

Another vent line attached to the DBB bleeding facility (if required) will be maintained opened.



All the vent lines shall be fitted with a diffuser at the surface manifold in order to dilute the exiting gas with gaseous nitrogen so that the concentration of the exiting gas is less than 15% of LEL. The venting operation shall be permanently monitored using a gas detector.

10.7 Monitoring during hot tapping operations

10.7.1 Hydraulic power pack output during trepanning

The hydraulic pressure shall be recorded during the trepanning operation for both the onshore trials and the offshore operation.

An accurate graphic record shall be produced showing the pressure variations during the onshore trepanning phase and the results obtained cross-checked with the findings of the offshore operation.

A graph shall be used during the offshore operation to confirm that each step of trepanning is occurring as planned, e.g. pilot drill starts penetrating, pilot drill through, cutter initials trepanning, etc.

The graph scale shall be determined to allow an easy identification of each trepanning sequence.

10.7.2 Pressure inside the branch stack up during trepanning and boring bar excursion

The pressure inside the valve stack up shall be monitored at all time during the hot tap operation to ensure that it does not exceed the equipment certification and approved hot tapping procedure requirements. The pressure shall be recorded on a chart and be part of the as built final documentation.

10.8 Reinstatement of anticorrosion coating

At the completion of the trepanning operation and prior to the installation of the protective structure, the anticorrosion coating onto the hot tap arrangement must be installed using retrowraps and amogel gel (see figures 3, 4 and 5 in Appendix 1).

11. Protection structure installation

The protection structure, when required, shall be made of two sections.

The lower section shall be set into position prior to perform the hot tapping, with the upper section being installed after the hot tapping has been performed. Particular care shall be taken to avoid contact with the hot tap piping and the upper section of the protection structure. Positive guide posts are to be used to set the upper section.

The lower section protection structure can be used as a temporary support to set the trepanning machine handling frame.



12. Completion file

After completion of the offshore works, all documents required by this specification shall be submitted to COMPANY. As a minimum and in addition to those mentioned in paragraph 8 "Work preparation", the following documents must be provided:

- Hot Tap Machine certification
- Pressure test equipment certificates
- As-built dossier.

Appendix 1

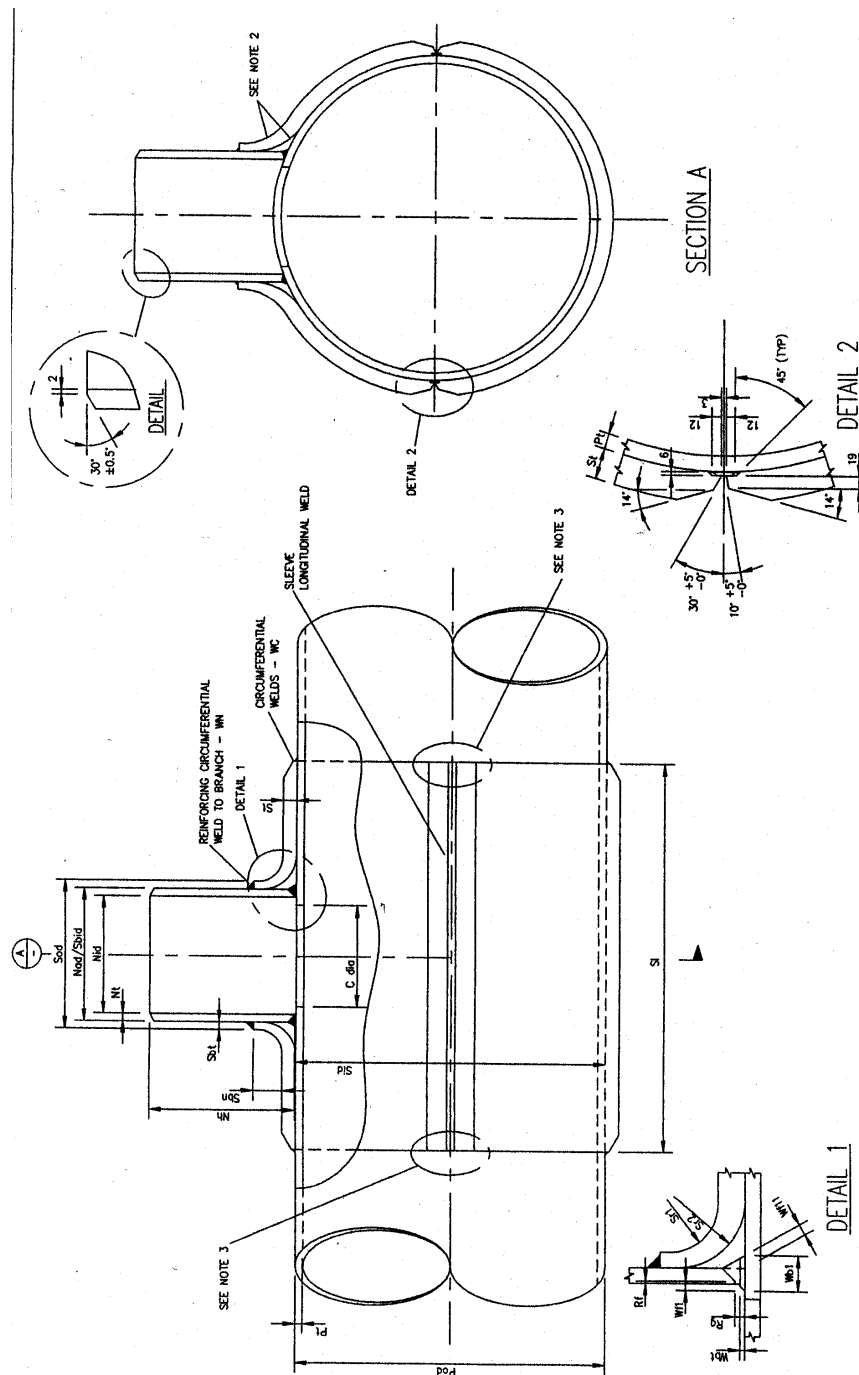


Figure 1 – Typical hot tap connection arrangement

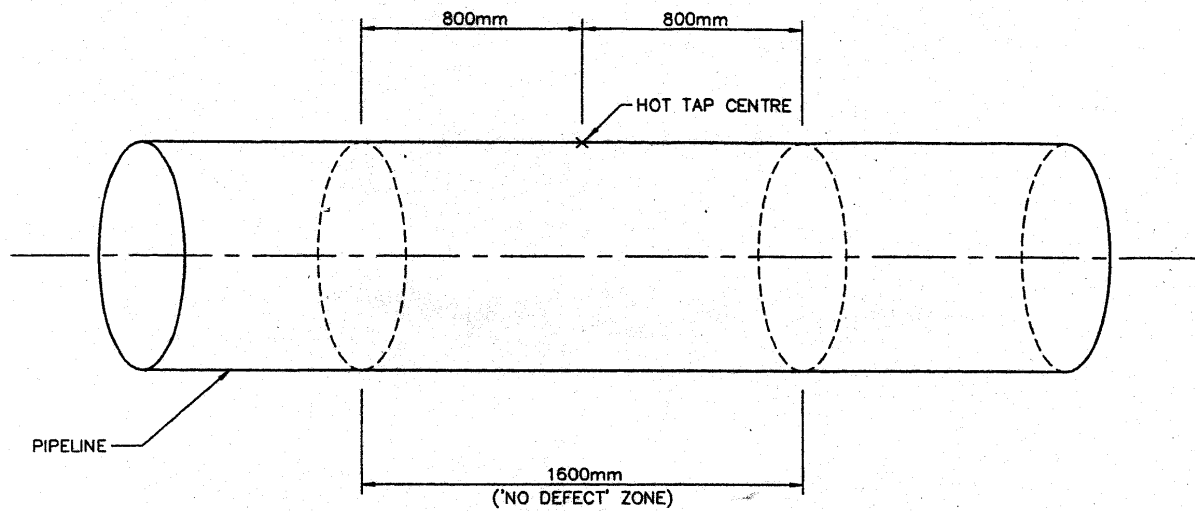
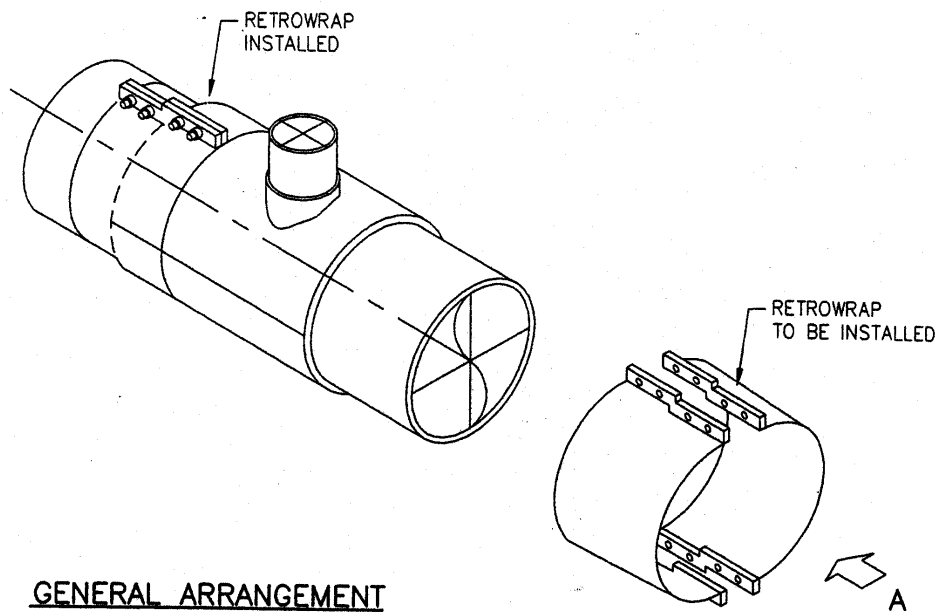
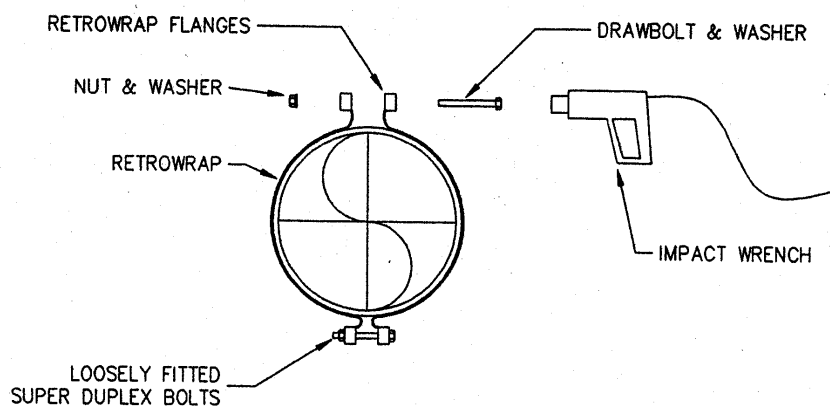


Figure 2 – Sketch for hot tap centre positioning

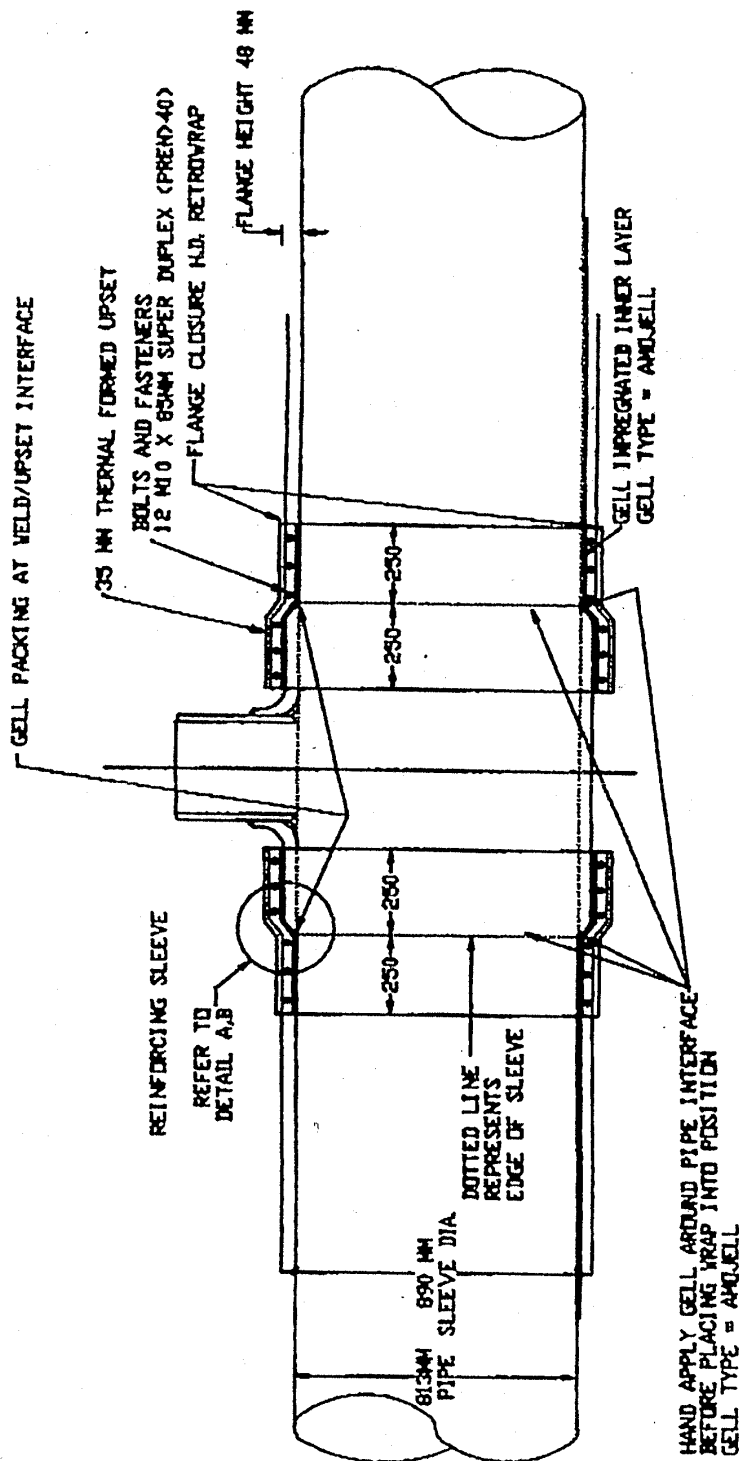


GENERAL ARRANGEMENT



VIEW ON ARROW 'A'

Figure 3 – Retrowrap installation – General arrangement



SEE INSTALLATION PROCEDURE FOR DETAILED INSTRUCTIONS.

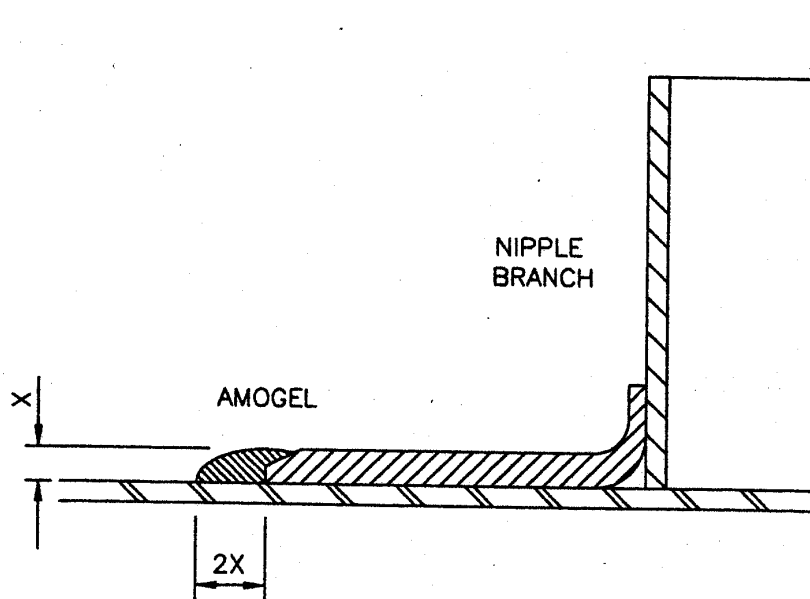
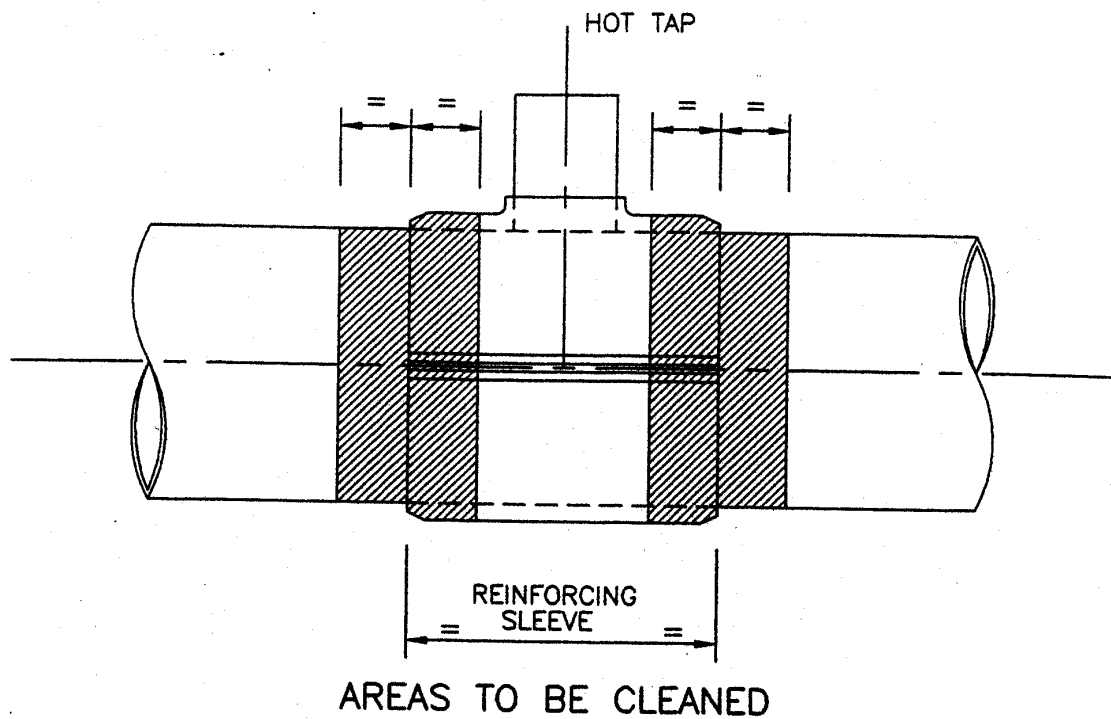
'RETROWRAP HD' IS OF MONOCOSMIC MULTI LAYER NYLON REINFORCED ABRASION RESISTANT POLYURETHANE TYPE R/2-90UF. SEE TECHNICAL SPECIFICATION FOR FULL DETAIL.

CC	Corrosion Control International 30 Beach Street Sydney, N.S.W. 1585 Tel: (02) 856-7662
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TOTAL ROSS TIE IN PIPELINE COATING REPAIR

NOTE: ANTI-FOULING AGENT MUST BE APPLIED TO THE EXTERIOR

Figure 4 – Hot tap arrangement – Coating repair



APPLICATION OF AMOGEL FILLET

Figure 5 – Application of Amogel fillet