Introduction

- A hot tap was required on the 12" Simonette high-pressure dehydrated sour gas transmission line near Grande Prairie.
- The hot tap was completed under full line pressure and gas/condenstate flow during the winter with temperatures averaging -20°C.
- The 12" transmission line gas is approximately 2% H_2S and 4% CO_2.
- New gas through 4" hot tap tie-in was 21% H_2S and 5% CO_2.

Key Technical Challenges

- Ensuring that all work can be carried out safely
- Achieving a final weld where all hardness are below 248 HV_{500} while welding on a pipeline with a quenching medium of flowing gas and condensate
- Preventing cracking due to hydrogen charging of the weld from in service interstitial hydrogen
- Preventing burn through of the pipeline while welding

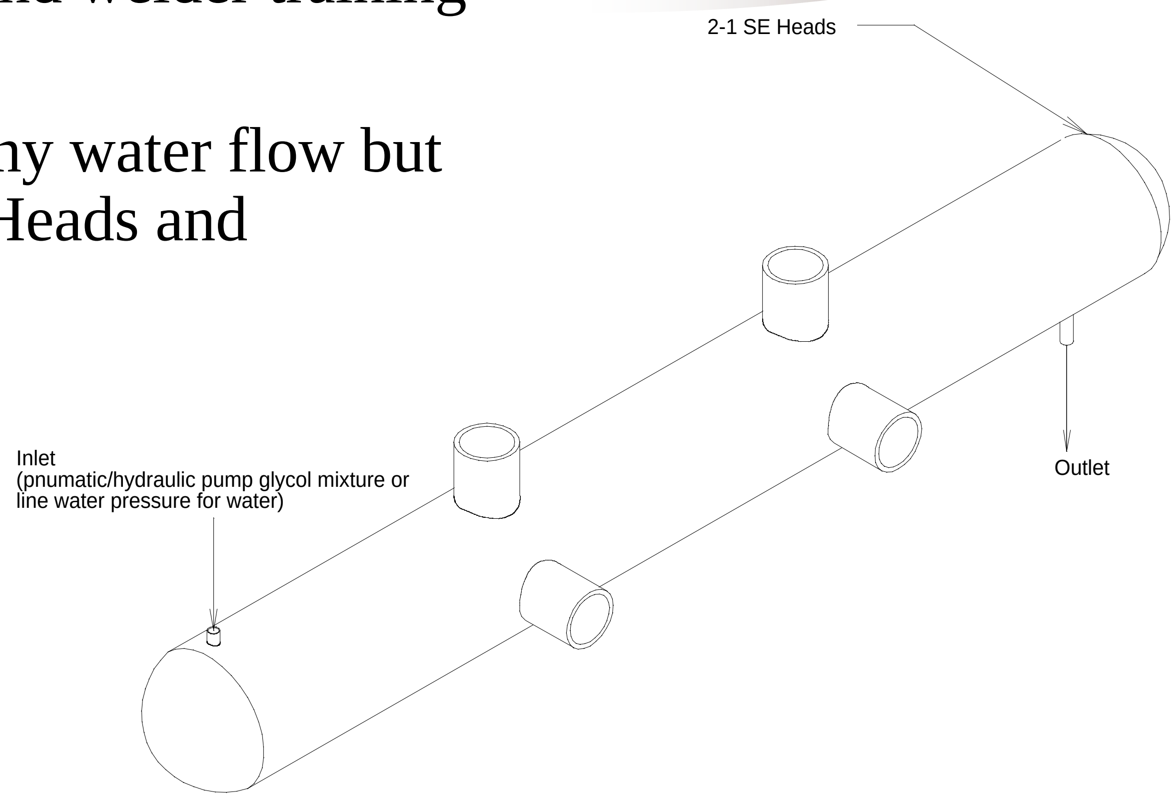
Safety Considerations

- CCR developed safety procedures to ensure that risk to the field staff was minimized.
- Due to the wall thickness and fracture properties of the pipe there was a very low risk of burn through or cracking to failure during the welding process.
- The most likely failure scenario would be a crack of the weld root after exposure to sour production resulting in a gas release around the reinforcing saddle.
- There was a safety specialist on site at all times during the procedure and an evacuation and emergency shut down plan was in place.

Coupon Details

- Large enough to facilitate the needs of PQR development and welder training

- Coupon similar to any water flow but was equipped with Heads and Hydrostatic tested.



Coupon Quench Media Details

- The first PQR welding was conducted on a pressurized length of pipe containing a 50% ethylene glycol/water solution as the cooling media.
- The second PQR welding was conducted on the same coupon but this testing was more conventional as it employed flowing water as a cooling media.

Material used for PQR's

- CSA Z245.1 323.9 x 11.3 mm wall Gr. 359 Cat II HIC resistant steel.
- Documented actual pipe was available for developing the weld procedure.
- Spark spectrographic analysis of the material verified the composition.
- Low Carbon Equivalent of 0.23%.

Weld Procedure Development CSA Z662-96

- Bend Testing
  - -Four face bend tests; one from each quadrant
- Macroscopic examinations (10X)
  - -Four Macro specimens; one from each quadrant
- Microhardness testing
  - -Two Macro hardness testing one from each 3:00 and 6:00 positions

Welding Parameter Details

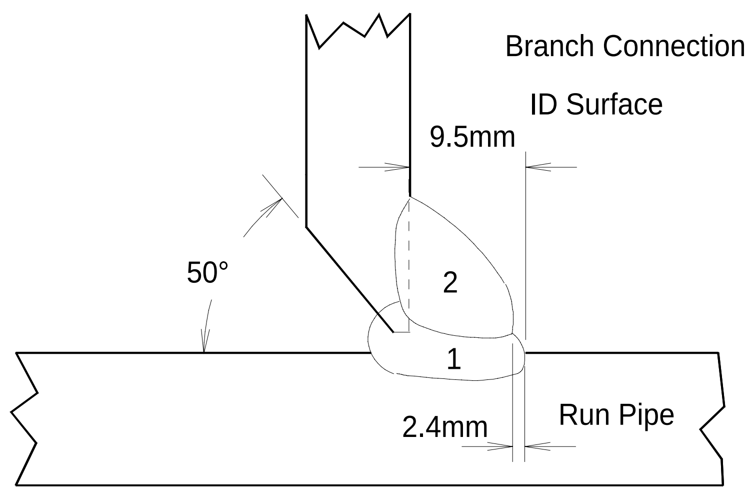
• Process	SMAW
• Consumable	E48018-1
• Consumable Diameter	2.4mm (all)
• Heat Input	2.3-4 kJ/mm(Tr. Spd. Controlled)
• Progression	Uphill

Weld Joint Design

- A critical aspect of the hot tap weld was the welding sequence. The weld sequence had to be be carried out such that each pass adequately heat treated or tempered by the pass which follows.
- The final cap pass, both inside and out, was made entirely on the previous weld metal and the branch connection pipe. These final passes must not be welded onto the carrier pipe as the resulting heat affected zone (HAZ) may be non-tempered and unacceptably high hardness would result.

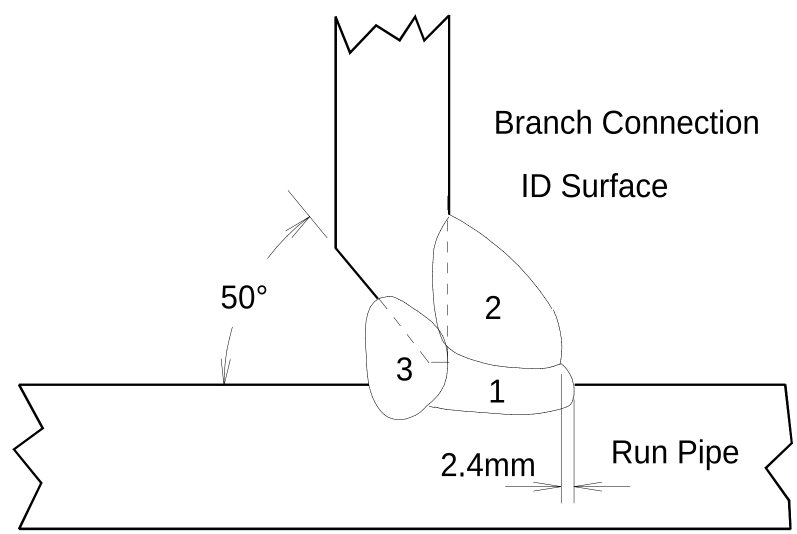
Weld Groove Preparation and Pass Sequence

- Pass 1 is on the inside of the branch connection and two thirds of this pass is applied to the run pipe material.
- Pass 2 on the inside of the branch connection is welded completely on the first pass or the nozzle material. This will temper Pass 1.



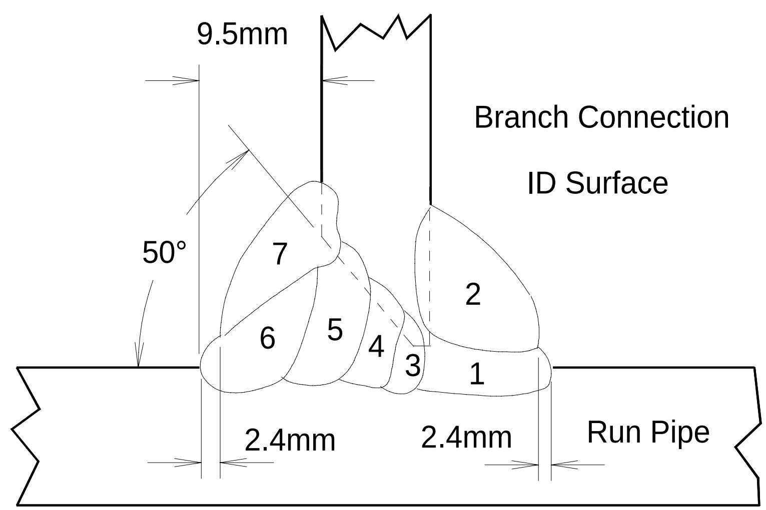
Weld Groove Preparation and Pass Sequence

- Slag from Pass 1 is removed by grinding to facilitate sound OD root pass installation.
- Pass 3, 4 and 5 are installed with approximately even weld metal to the branch and run pipe



Weld Groove Preparation and Pass Sequence

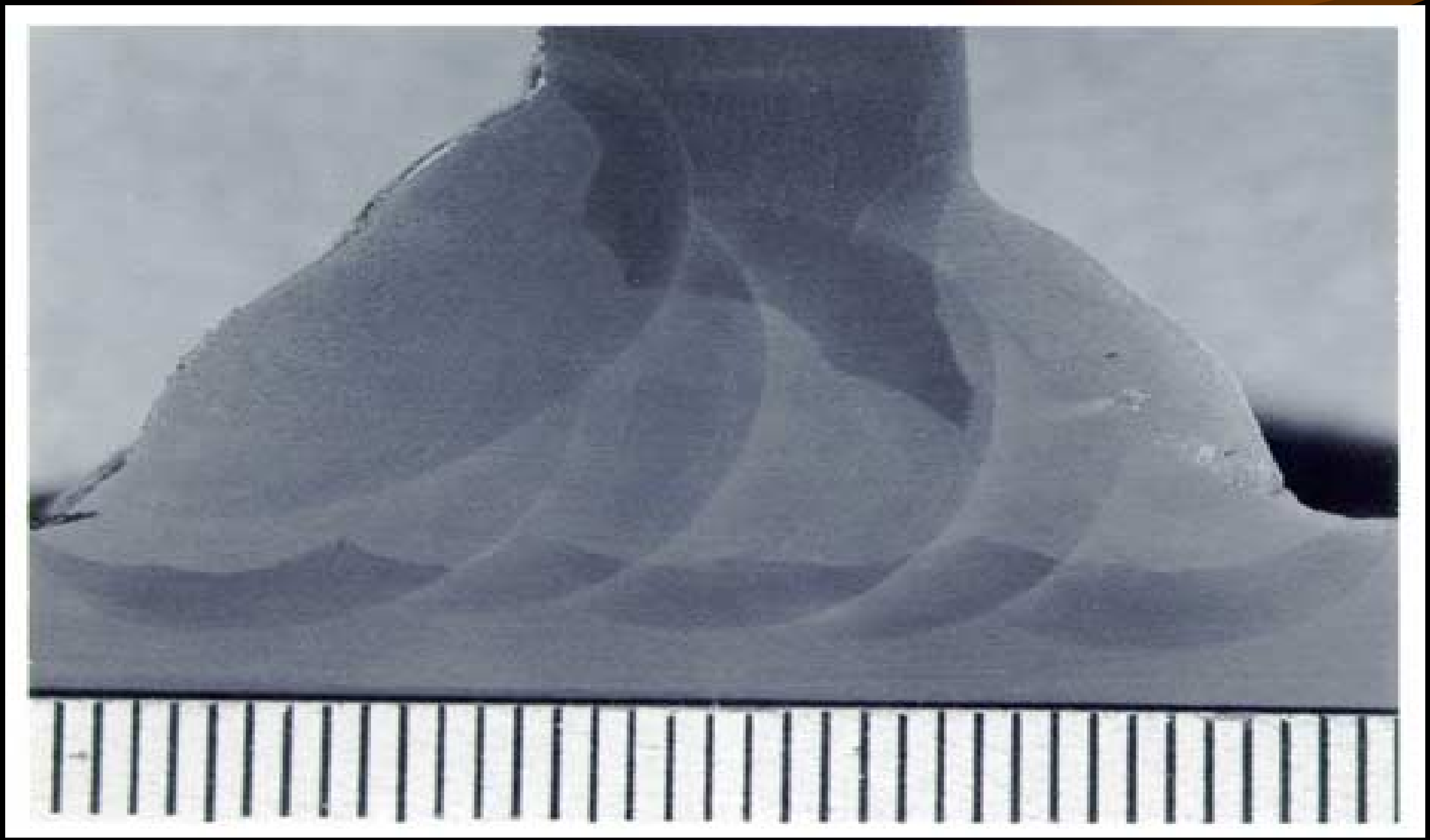
- Pass 6, the second to last pass has two thirds of the weld applied to the parent material.
- Pass 7, the last pass on outside of the branch connection has 100 % of the weld on Pass 6 or the nozzle material



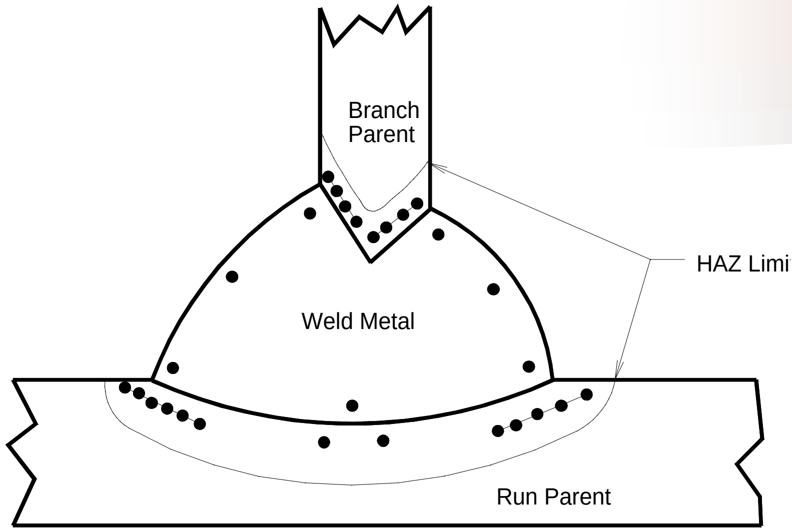
Test Results

- All bend testing passed
- No rejectable flaws observed with macro examinations
- All Hardness testing produced acceptable results (< 248 HV_{500})

Test Results Macro examination

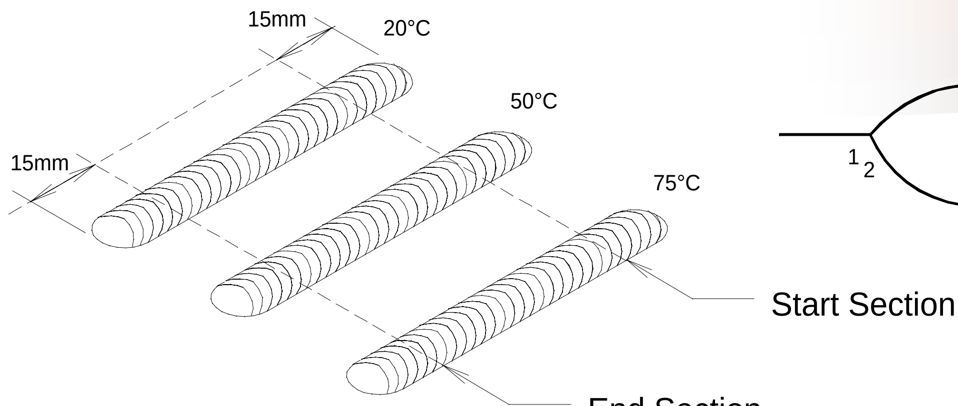


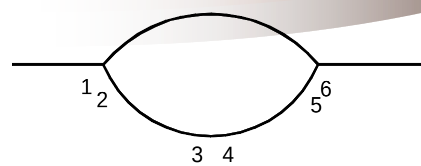
Hardness Test Result Summary



	HAZ HARDNESS (HV_{500})			
	Water		**50% ethylene glycol / water**	
	Branch	***Run***	***Branch***	***Run***
Hardness Range	172-211	163-228	172-223	188-227
Hardness Average	184	200	195	210

Capable Hardness





			Hardness (HV_{500})				
	Start Section				Finish Section		
Test Pt.	**20°C**	**50°C**	**75°C**		**20°C**	**50°C**	**75°C**
1	220	192	185		264	227	220
2	215	207	180		302	224	235
3	273	234	181		331	241	243
4	255	224	240		317	278	261
5	236	224	205		244	210	237
6	215	190	188		257	228	241

Training of the welder

- It is critical that the welder is educated in the correct technique prior to the hot tap.
- Typically, welders are trained to produced defect free welds and rarely consider weld hardness.
- The welder must weld with strict adherence to the procedure to attain the hardness levels required.
- The welder was required to attend a training session to understand the technical aspects of the procedure.
- The welder was also tested repeatedly on the same pipe size and orientation as that to be encountered on the hot tap.

Field Welding -Prior to welding

- At the location of the welded, a complete Ultrasonic Testing (UT) grid was performed for 600 mm on either side of the weld area.
- The UT grid scan was used to ensure that no corrosion had occurred and that the wall thickness is uniform and to check for any measurable inclusions or laminations.
- In addition to the UT, radiography was used to check the entire circumference of the area to be welded.

Field Welding- Prior to Welding

- Experienced technical staff was on site to confirm strict adherence to the procedural details such as preheat, rod size, pass sequence, volt and amp settings, travel speed and inter-pass temperatures.
- If problems occurred during welding or if preheat could not be maintained CCR was prepared to stop the work and shut in the pipeline if necessary.

Field Welding -Preheat

- Prior to preheating the pipe wall temperature was either 6 to 7°C or 2 to 3°C. The lower temperatures were believed to corresponded to condensate slugs.
- The stress reliever was ineffective at increasing the pipe wall temperature at the weld area during slugging
- A oxygen acetylene torch was used to maintain the preheat
- By preheating the pipe immediately prior to welding each electrode, the required preheats could be maintained.

NDE During welding

- The weld was MPI inspected for cracking a several stages
  - Root pass
  - After the welding was completed
  - 24 hours after the weld was completed to check for delayed hydrogen cold cracking.

Field Welding

- The reinforcement saddle was not welded to the carrier pipe wall.

Field Welding

- The reinforcement saddle is welded to the branch connection
- The completed weld of the reinforcement saddle to the branch connection was magnetic particle inspected. (Figure 6)

Completed Weld

Hot tap

- During the actual hot tap into the pipeline the machine operator was masked up and using supplied breathing air apparatus,
- H_2S detection was in place and a rescue crew was standing by.

Conclusions

- Preplanning for emergency is critical to ensure the safety of the personal doing the work.
- The weld procedure must be developed using a pipe of equal or greater CE, with the same diameter and wall thickness.
- The procedure development must duplicate the worst case quenching effects of the carried pipe fluid.

Conclusions

- The wall thickness of the pipe must be greater than 4.8 mm to prevent the risk of burn through.
- The carrier pipe must be un-corroded and free of laminations.