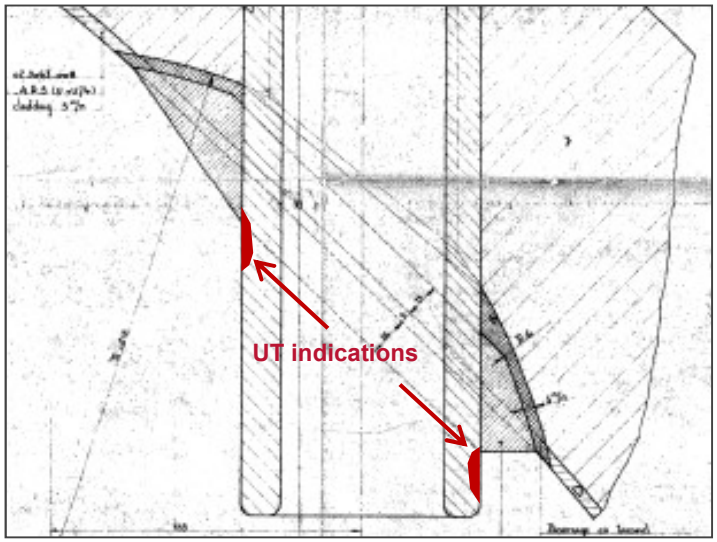
Repair of Doel 1 NPP Reactor Vessel Head Penetrations

International Workshop on Age-Related Degradation of Reactor Vessels and Internals, USNRC, Washington, 23-24/5/2019

TRACTEBEL ENGIE

Repair Reactor Vessel Head penetrations Doel 1
Status in June 2017

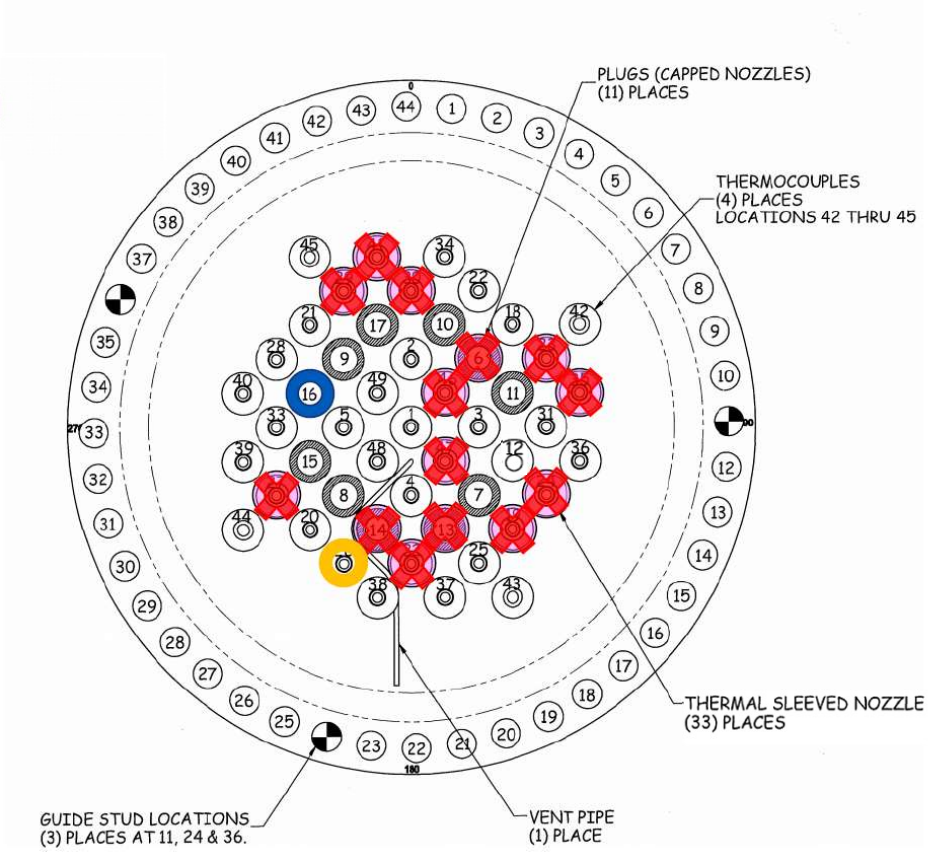
- 49 adapters
- VT: no degradation reported
- UT: 25 relevant indications in 14 adapters
  - OD surface indications, considered axial, close to J-groove weld fusion line
  - Since 2016, 2 new indications and slight growth of known indications (but << to predictions)
  - Justification for Continued Operation up to outage June 2018
  - Qualification of Inside Diameter Temper Bead repair in 2017
  - June 2018: ISI of all 49 adapters, and repair of 14 affected adapters



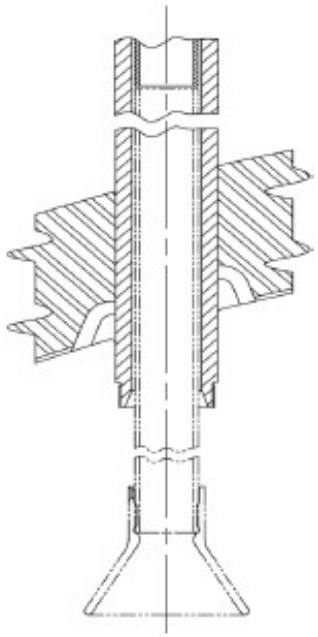
Repair Reactor Vessel Head penetrations Doel 1

Inspection and repair in 2018

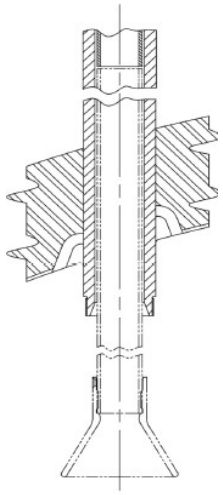
- Doel 1 – 2018: UT + repair by IDTB
  - Pre-ISI PWSCC locations
  - Originally scheduled (14) repair locations
  - Two new indications detected by UT in 2018
    - Penetration 26 : seen not reported in 2017
    - Penetration 16 : not observed in 2017
  - Total of 16 repaired penetrations



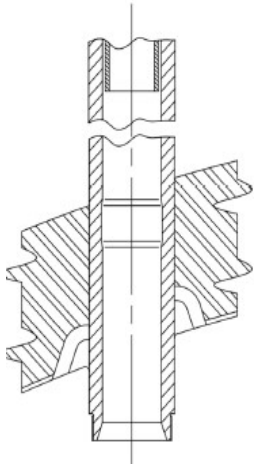
Repair Reactor Vessel Head penetrations Doel 1
IDTB Repair Process (1/2)



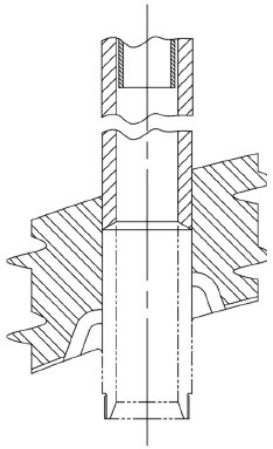
Typical Existing Configuration



Step 1
Cutting and Removal of
Thermal Sleeve

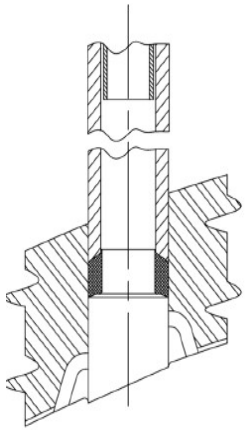


Step 2
Roll Expansion

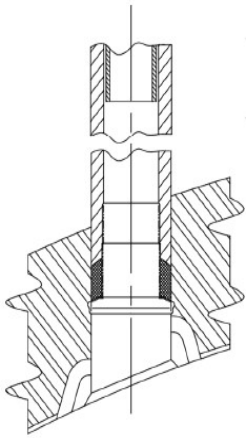


Step 3
Adapter boring, weld
Prep Machining and
manual PT

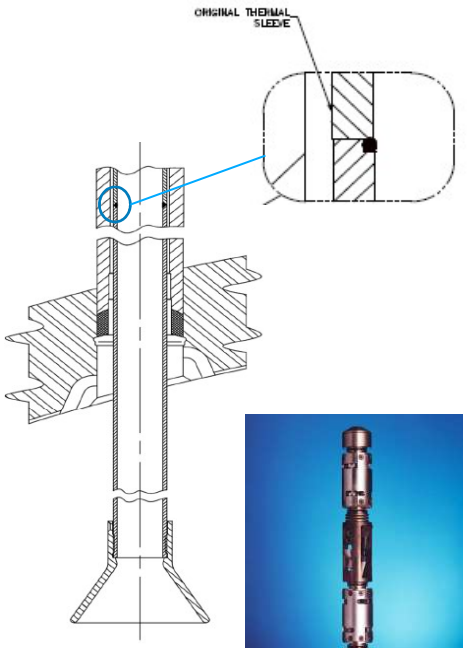
Repair Reactor Vessel Head penetrations Doel 1
IDTB Repair Process (2/2)



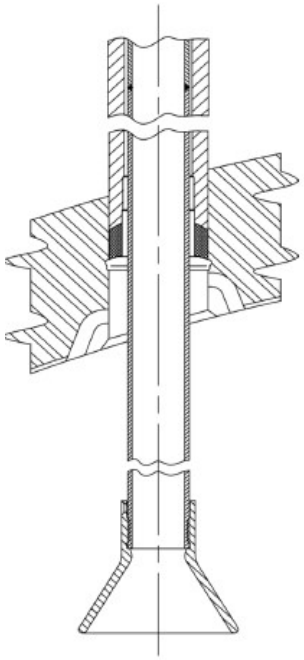
Step 4
Temper Bead
Welding (GTAW)



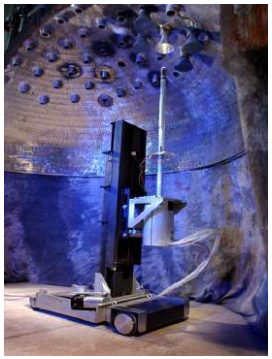
Step 5
Machining, UT,
automated PT, rotary
peening and PT



Step 6
Thermal Sleeve
Replacement



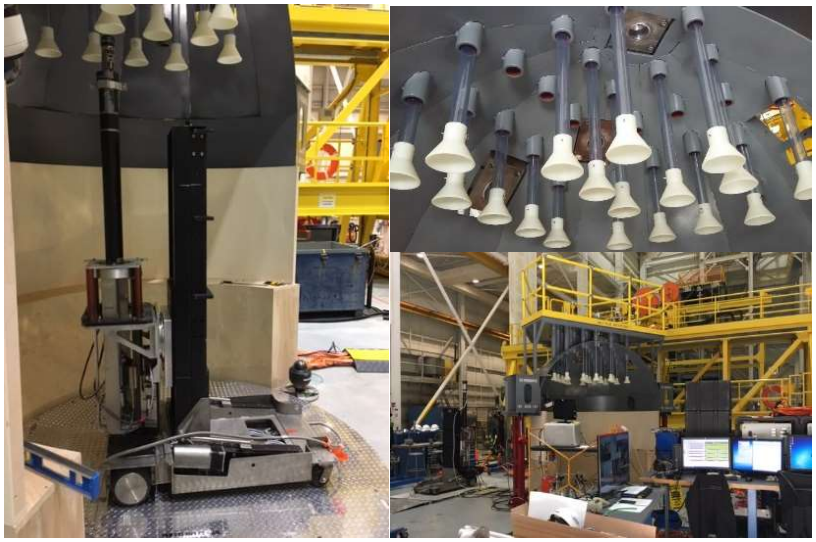
Typical Final Configuration



SUMO Rocky Manipulator

Repair Reactor Vessel Head penetrations Doel 1
Qualification of repair

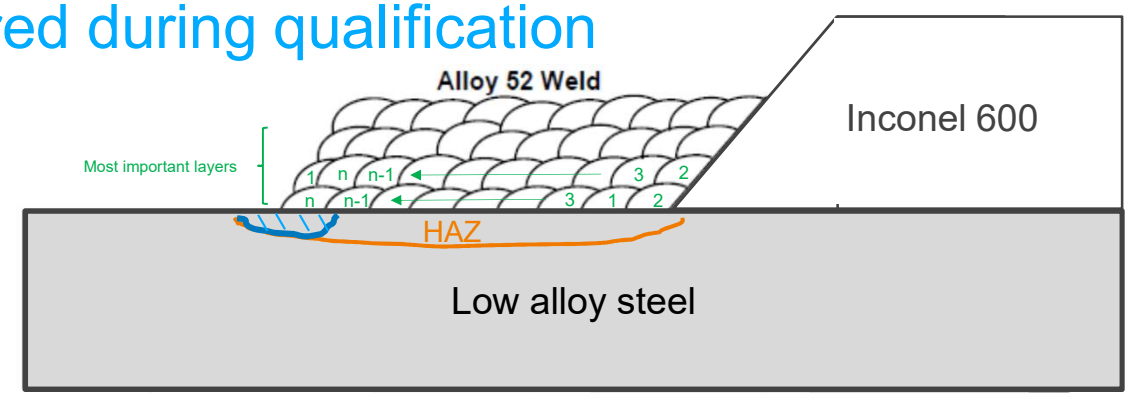
- Demonstration of full process on dummy half-head mockup

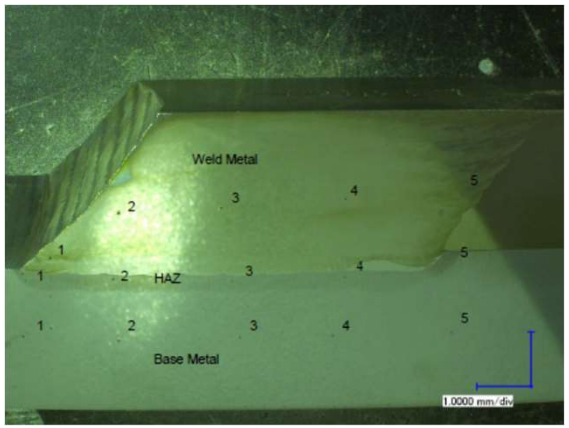


- Qualification of welding process, welders and welding products
  - Use of several test coupons
  - ASME IX requirements + additional tests

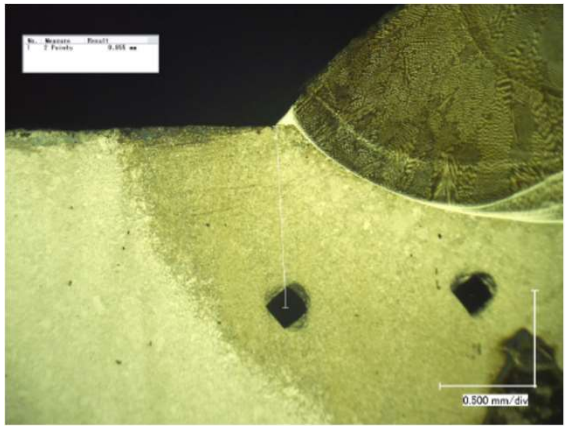
Repair Reactor Vessel Head penetrations Doel 1
Hardness issue encountered during qualification

- Hardness value in HAZ > 380 HV_{10}





Macrography



Micrography

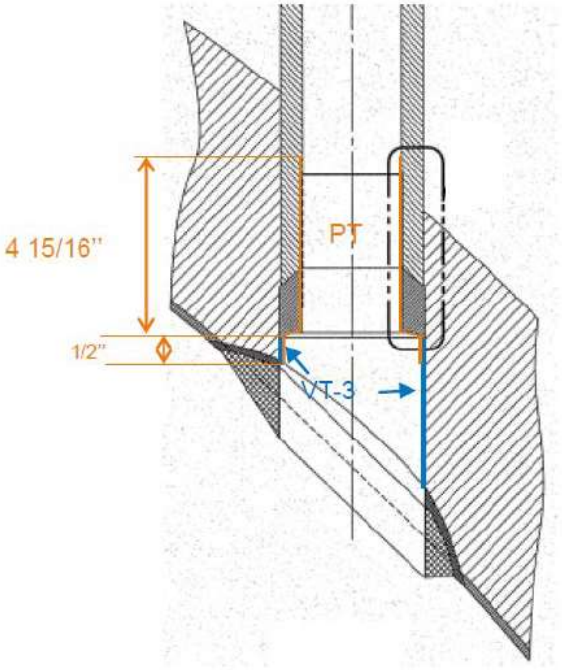
Sample	Vickers Microhardness HV10														
	Weld Metal Location					HAZ Location					Base Metal Location				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
IDTB02-HRD-01	200	205	229	225	226	360	321	316	296	351	271	214	216	208	215
IDTB02-HRD-02	241	221	211	248	236	434	301	298	296	320	280	194	195	195	203
IDTB02-HRD-03	205	189	228	222	239	390	307	312	312	343	242	199	206	201	205
IDTB02-HRD-04	180	187	217	216	208	367	298	354	277	314	191	195	192	203	213
Required	380 Max														

Repair Reactor Vessel Head penetrations Doel 1
Issues encountered during repair

- During qualification, welding parameters and sequence had to be optimized in order to have sufficient tempering and acceptable hardness values in HAZ
- During repair, breakdown of cutting tools used to cut and remove thermal sleeves
  - FRAMATOME Inc. never encountered this issue before
  - Issue may have been due to a very slight inclination of the thermal sleeves (approx. 0.5-1°)
  - Solution : tooling adaptations with tests done at Lynchburg and copied at Doel

In-Service-Inspection of repaired penetrations

- Without thermal sleeve



- With thermal sleeve