Defects in chord to spudcan connections, Noble Intrepid

Riggvedlikehold 26. Sept 2024

Sveinung Flystveit

Noble Intrepid

Design	Jack-up CJ-70 Gusto MSC design
Constructed	2014 – DNV class
Operational water depth /drilling depth	150 m / 12 000 meter
Weights (Floating / elevated)	31 485 tons / 21 500 tons

UWILD - Underwater Inspection in Lieu of Dry-Docking

Requirements

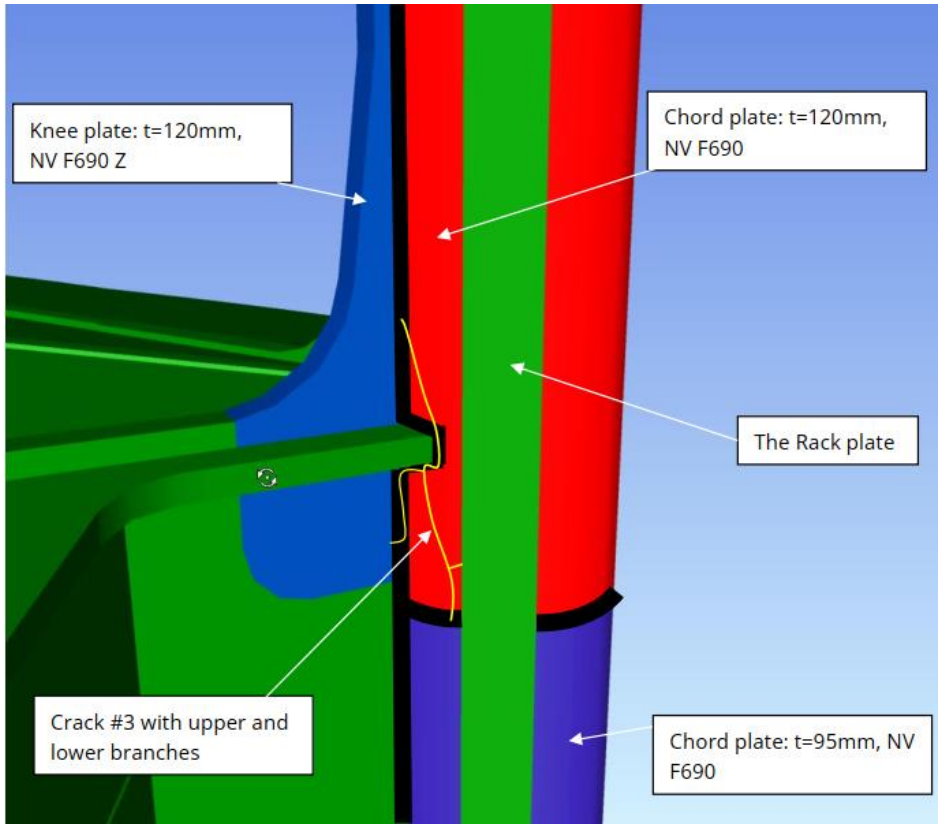
- Inspection of the MODU following the class In-Service Inspection Plan (IIP)
  - Intermediate inspection (2,5 years)
  - Renewal (5 years)

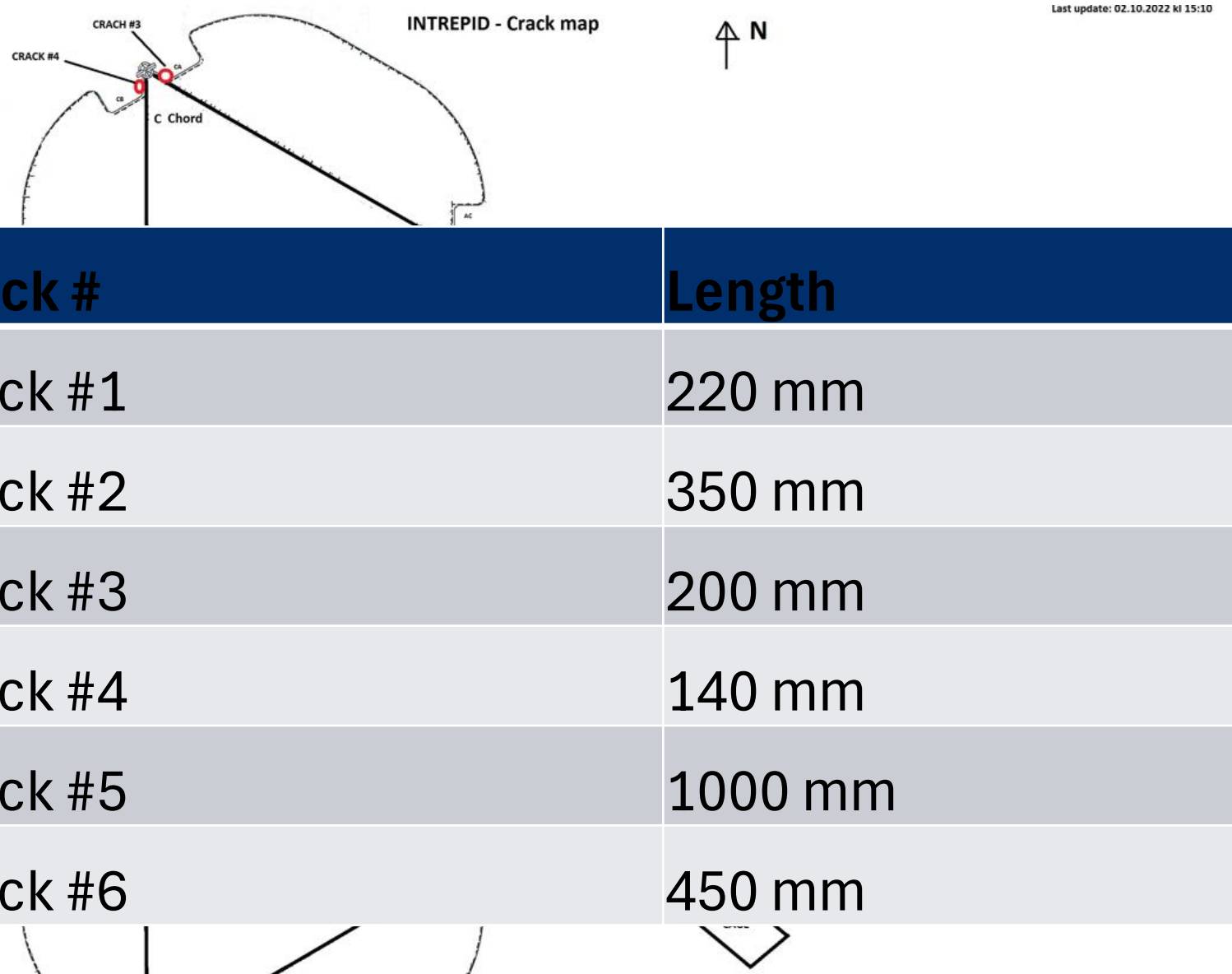
Noble Intrepid (2022)

- Intermediate Inspection performed by use of Work class ROV
  - Cleaning of spud cans done by ROV with HP washer
  - Structural inspection performed by camera with NDT inspector and DNV surveyor onboard
  - The structural inspection is a combination of general visual inspection and close visual inspection

Spud can


OCEANEERING
S
196
SW
Dive 29
DPT 92.0
Alt 1.0
CUI Chord C to spudcan vertical connection ca 10:40:48
Intrepid UWILD 2022 Leg #3
04.09.22


Knee plate: t=120mm, NV F690 Z
Chord plate: t=120mm, NV F690
The Rack plate
Crack #3 with upper and lower branches
Chord plate: t=95mm, NV F690



Crack #	Length
Crack #1	220 mm
Crack #2	350 mm
Crack #3	200 mm
Crack #4	140 mm
Crack #5	1000 mm
Crack #6	450 mm

What do we do next?

- Notify Havtil
- Internal engineering
- External support from GustoMSC and Force technology

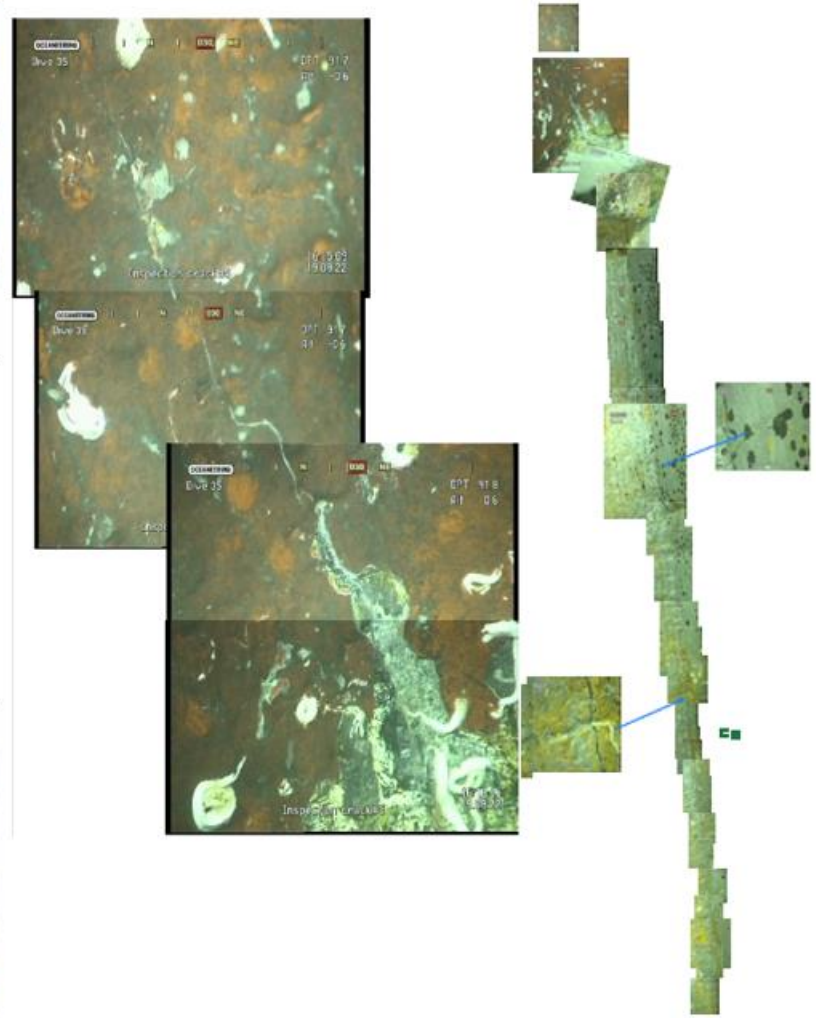
- Continous correspondace and meetings with DNV

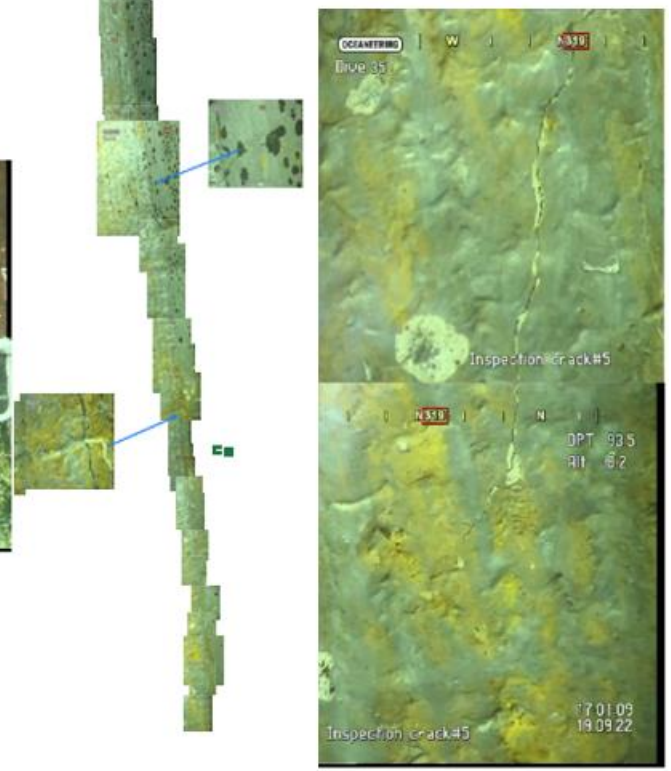
- Mobilize UT / ACFM equipment to for further investigation

- Develop inspection procedure for continous monitoring of cracks

- Mobilisation of UT subsea crew to confirm indications to be cracks in metal beneath coating
- Crack depth measurements of up to 91 mm but no water in chord
- Periodic visual ROV inspections to confirm no crack propagation
- Root cause analysis
- The failure mechanism causing the observed cracks is hydrogen assistant stress cracking – not hydrogen embrittlement. The cracks will not propagate fast.
- Prove remaining structural strength to continue operation
- Removal of anodes from Spud can (hydrogen point source)

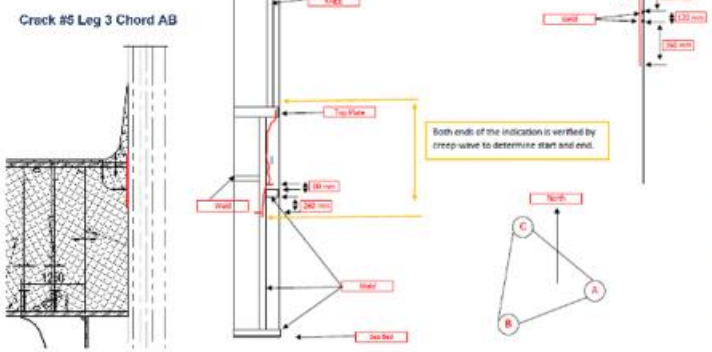
Indication #5, Leg 3, chord A, A/B side



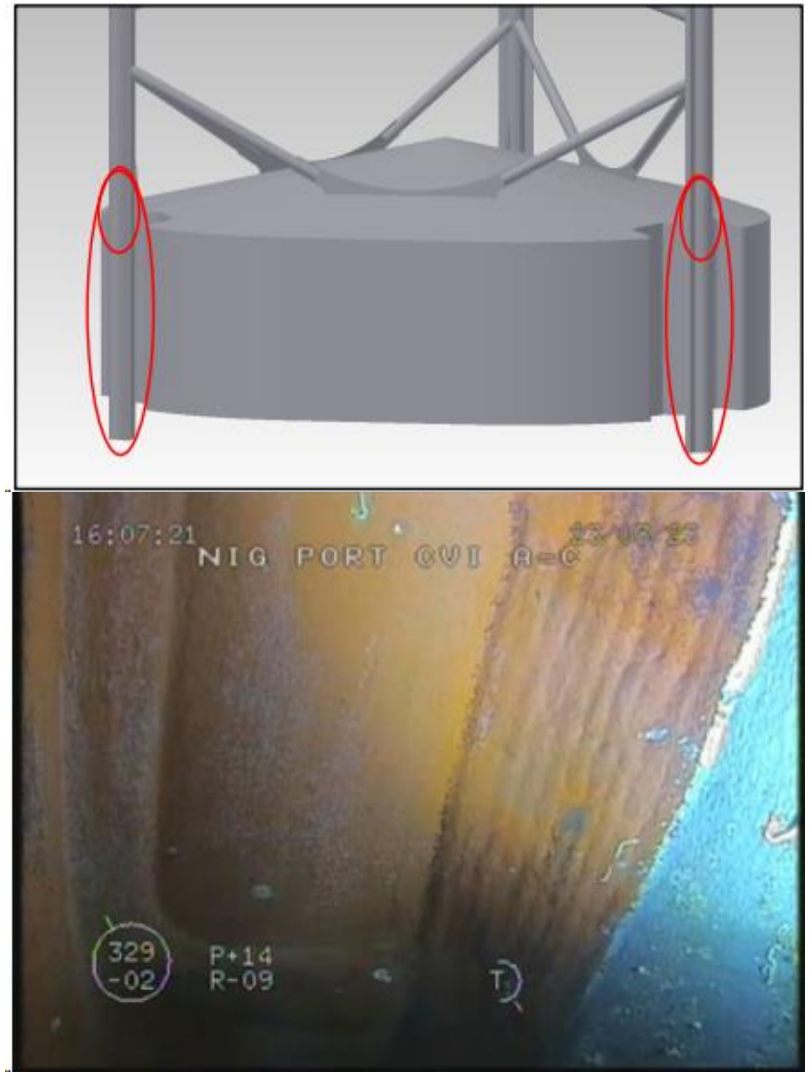


Leg #3 A-B Crack 5

Length of crack in mm	From 100 mm up from top plate + 100 mm top plate	To 860 mm below top plate
Maximum depth of crack in mm	81 mm	
UT highest point marked with blue	Length -	Depth 81 mm
Lowest reading with UT		
Wall thickness 120 mm		



Other units



- Develop Noble Bulletin IB-2020-10-12 for offshore inspection
- Inspection method: Close Visual

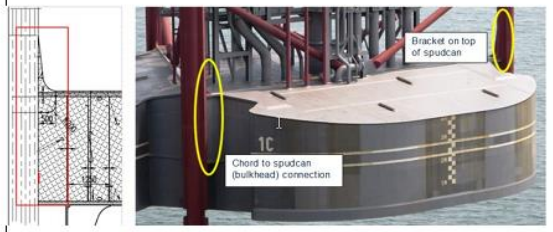
Internal Technical Bulletin

OEM:	Gusto MSC	Bulletin Number:	IB-2022-10-12
Bulletin Type:	Additional inspection	Equipment Affected:	Spudcans structure
Bulletin Date:	12.10.2022	Rigs Affected:	J114, J115, J116,
SFI	226	MOC	-
Created by	KPO024	Approved by	

GENERAL DESCRIPTION OF BULLETIN

During INTREPID UWILD ROV inspection on September 2022, cracks were discovered on Spudcan to Leg Chord structure. In toatal 6 cracks have been observed spreaded on three legs. The cracks are inspected by ROV twice a week to check if they are propagating. From the beginning of September to early October no extension of the cracks have been noticed. The rig designer GustoMSC prepared a analysis of residual strength of the Intrepid footing to check if the rig can continue operation for the current location and site specific conditions. The FE-model analysis showed that the spudcan structure has sufficient remaining strength for the site-specific conditions even with cracks developed to longer length than in current view. Propable cause of the cracks is "hydrogen induced stress cracking".

See below Ref.1.- the area of intrest, the map with the Intrepid cracks (Ref.3.) and some examples of pictures from Intrepid ROV inspection (Ref.2.). Also see enclosed some pictures from the spudcan 3-d model, for better understanding the area of cracks occurance.



Ref.1. The area of interest

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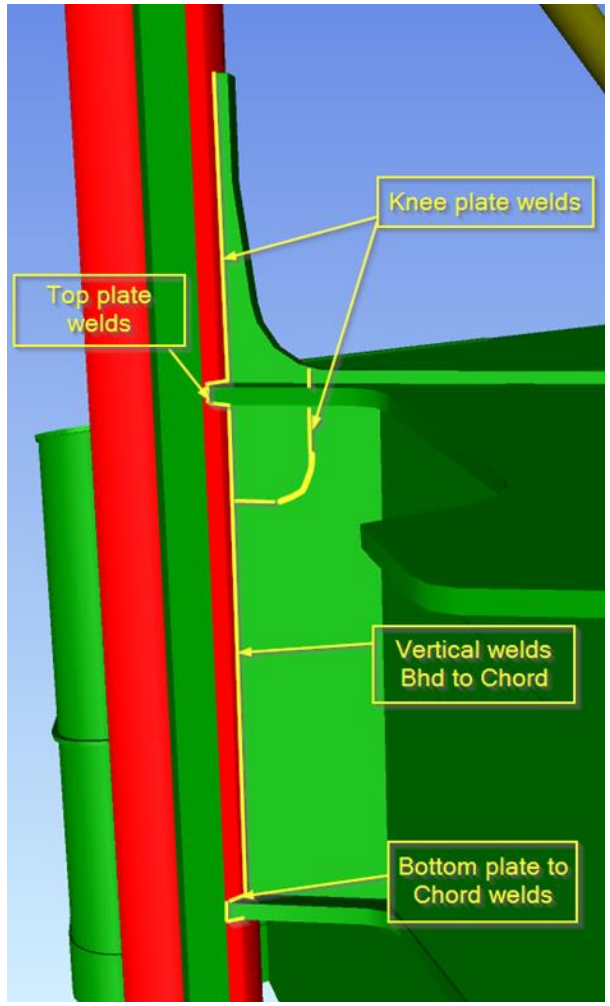
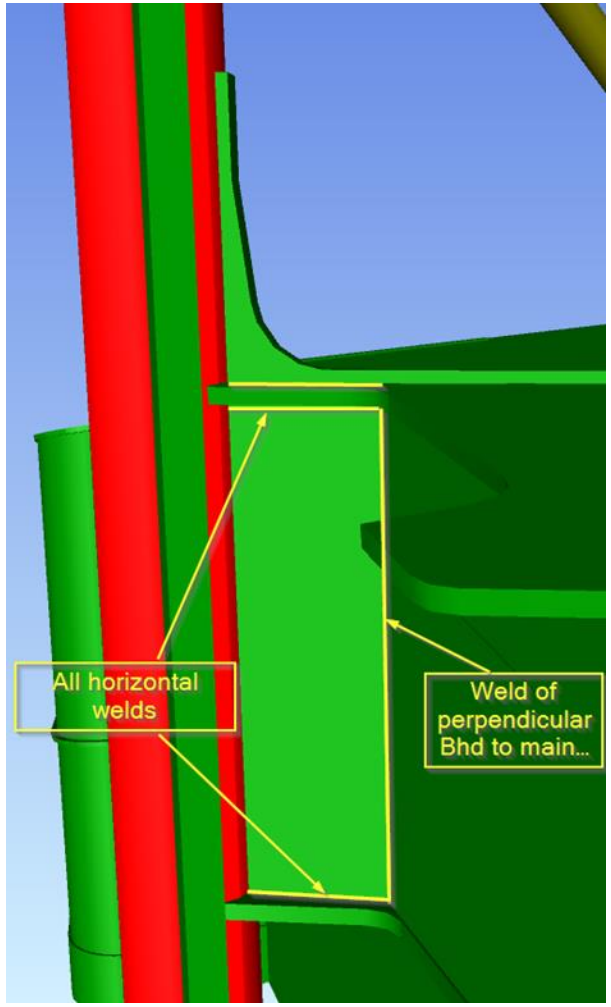
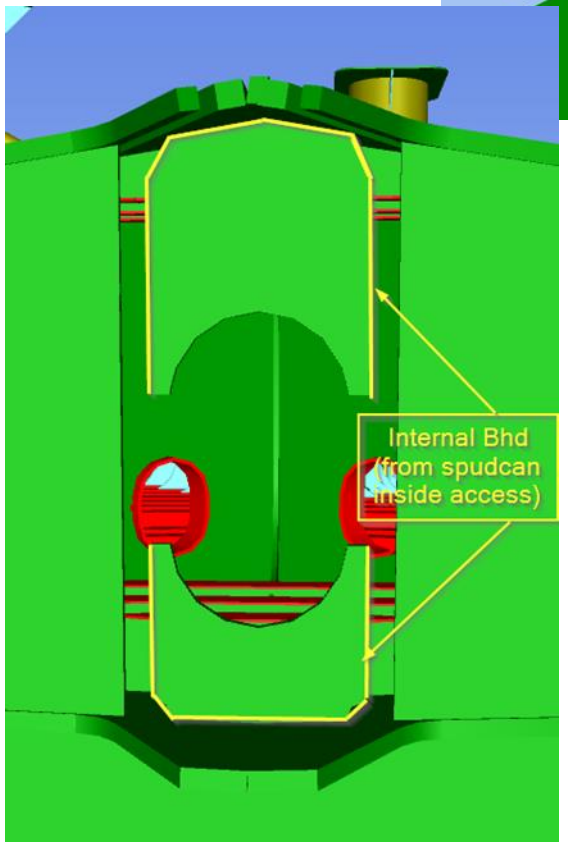
INTREPID
FERGUSON

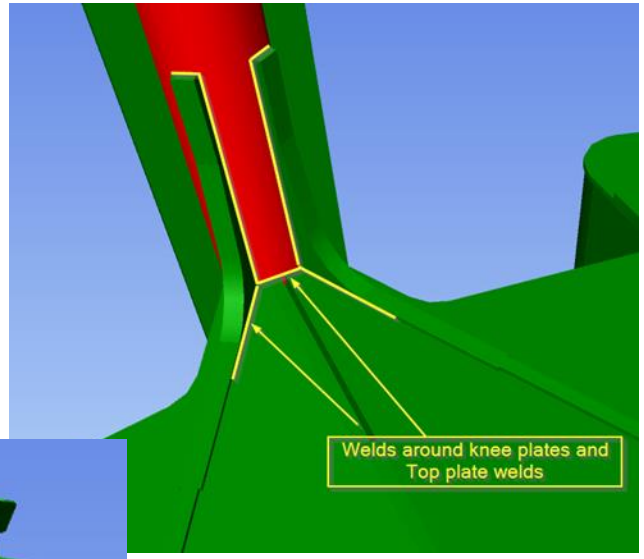
Inspections during dry docking

The following areas were 100% CVI & ET inspected









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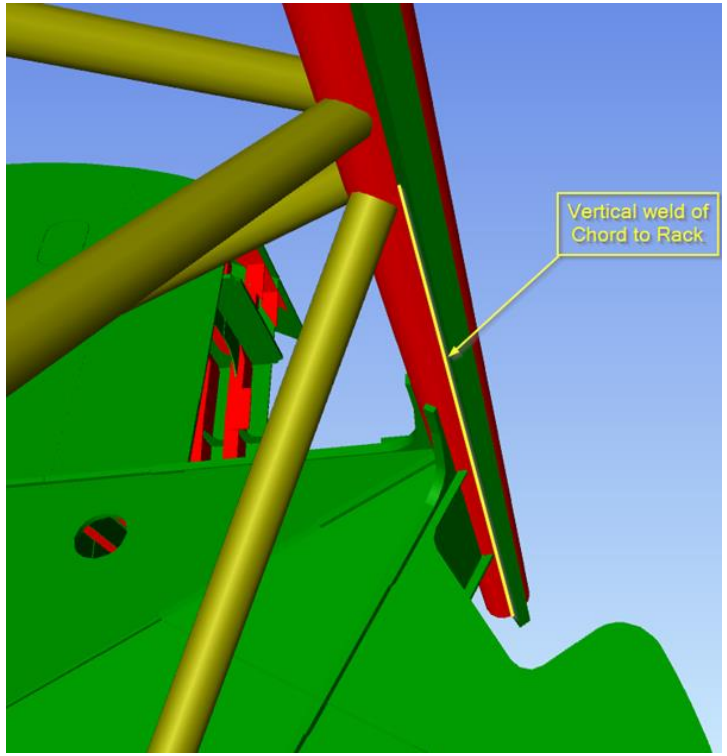
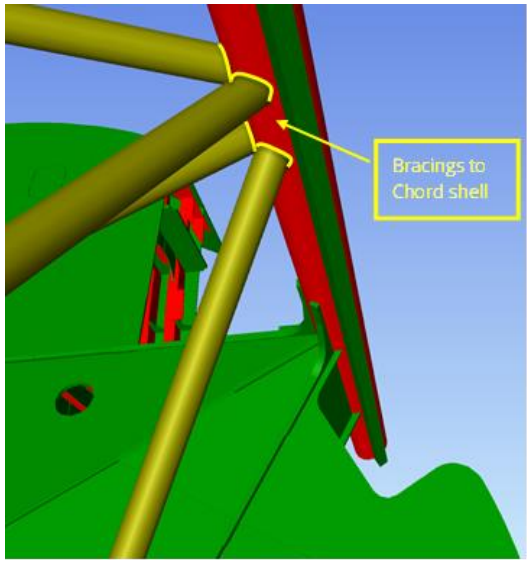
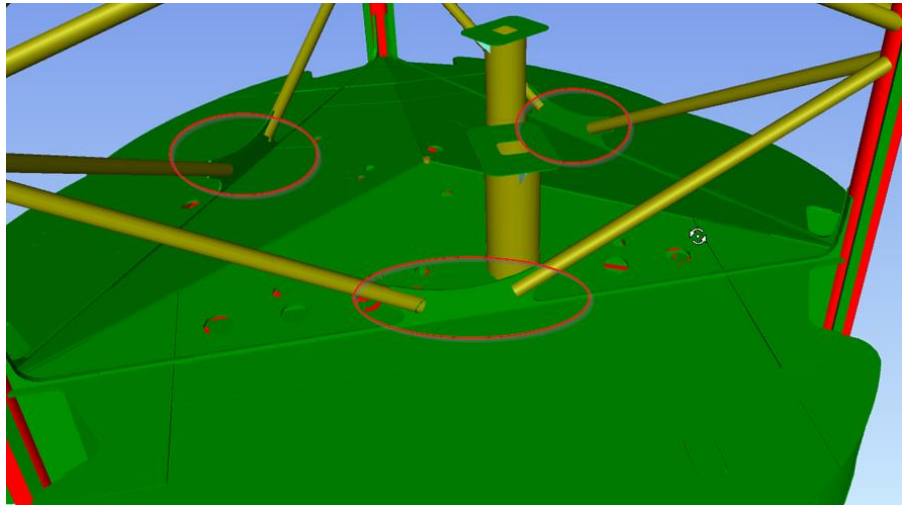
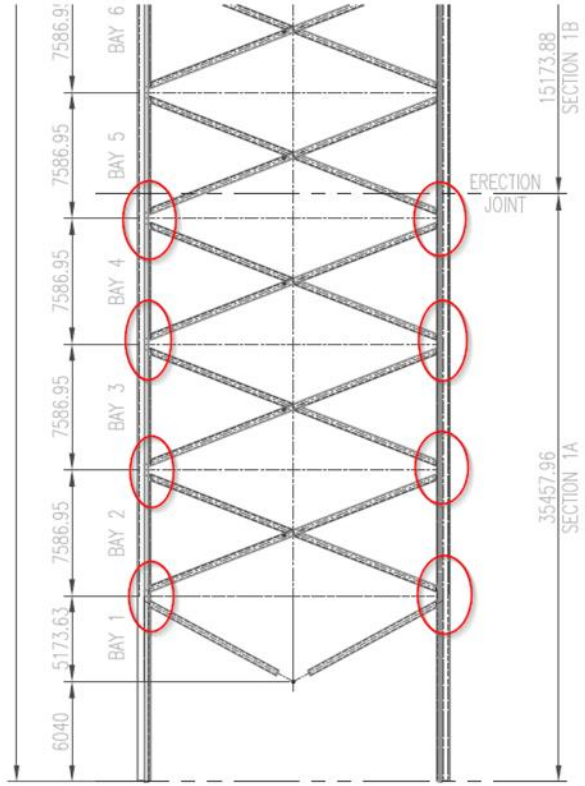


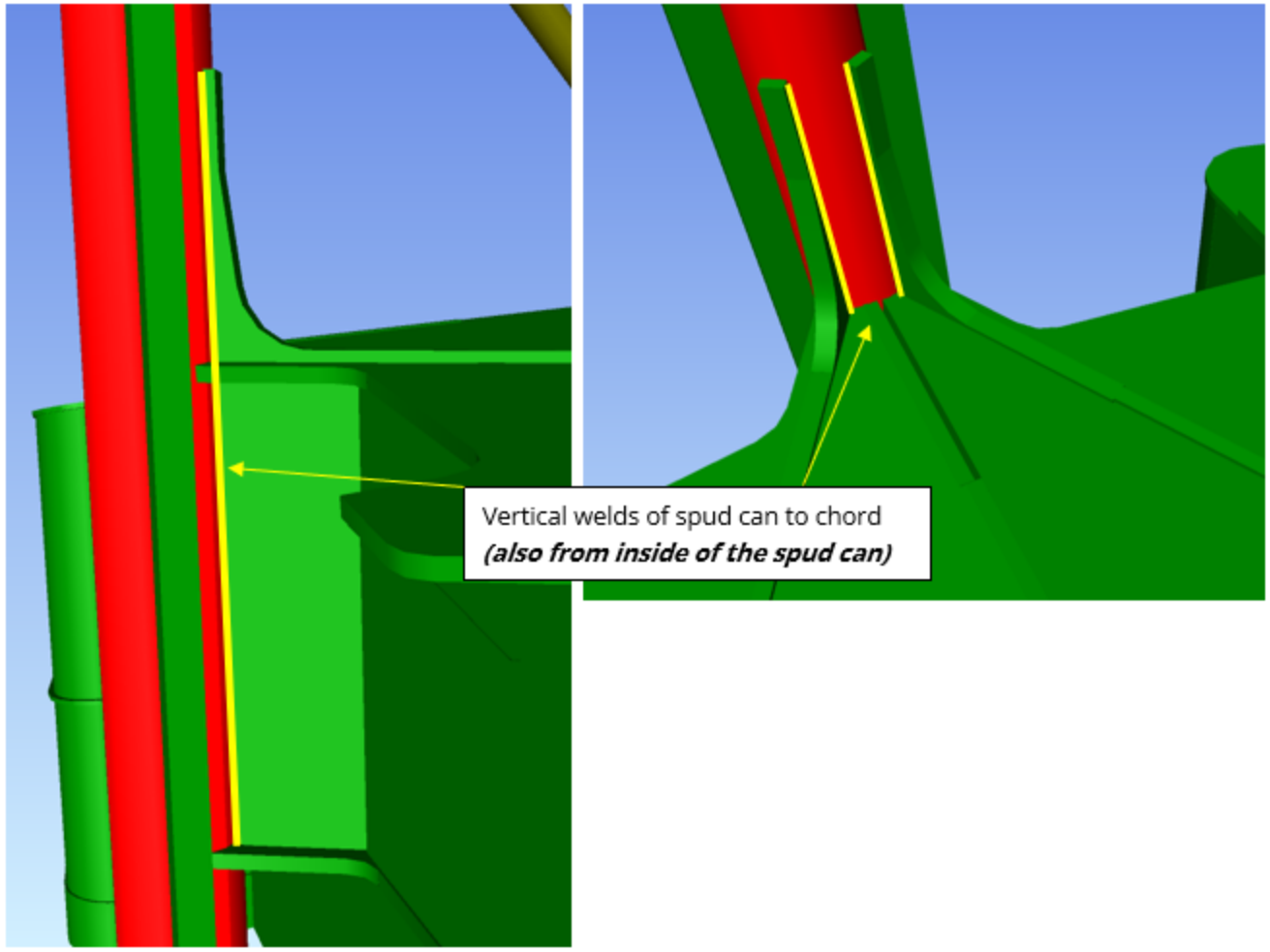






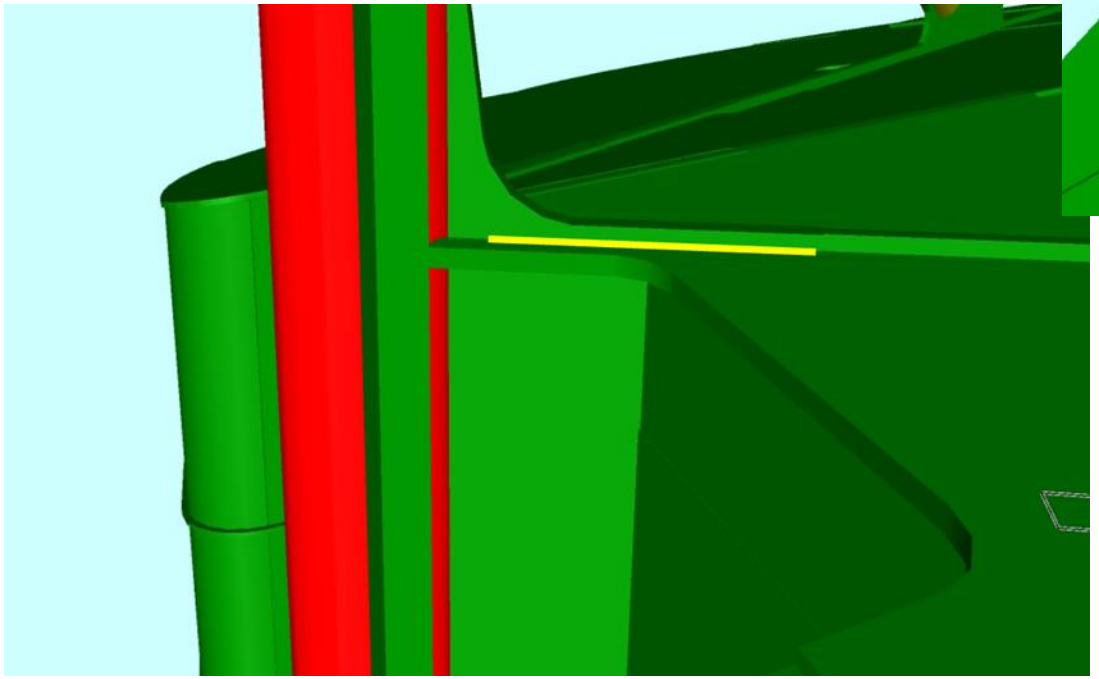
Inspections during dry docking

The following areas were 100% UT inspected for transverse cracks.

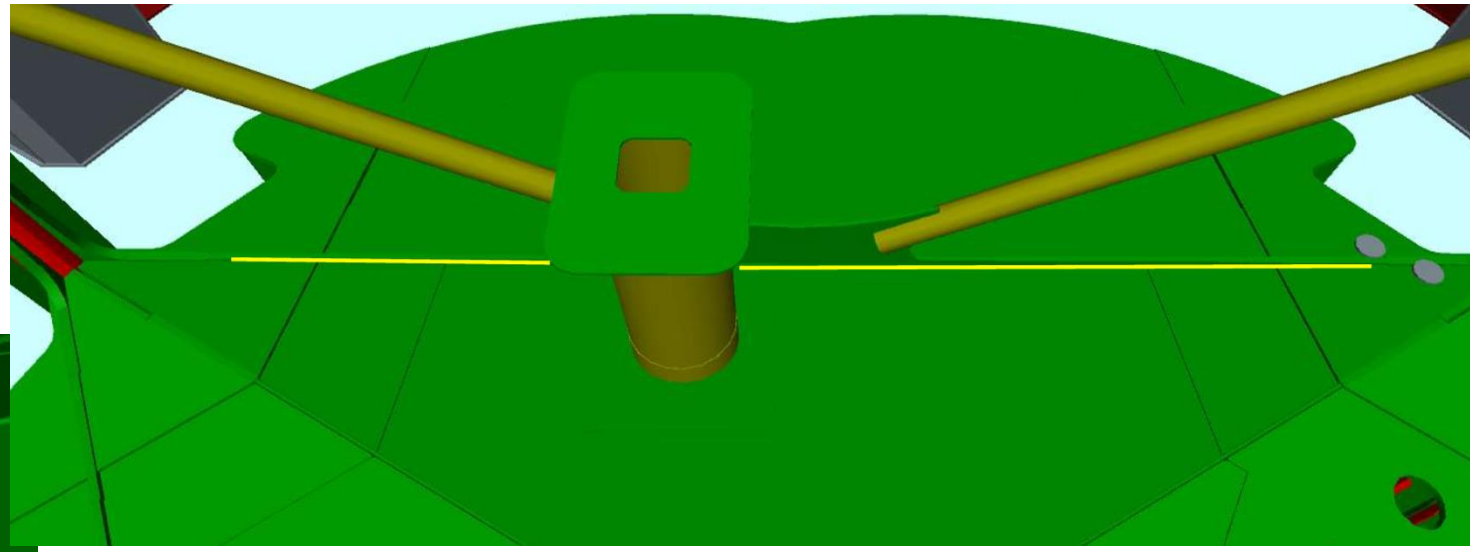


Inspections during dry docking

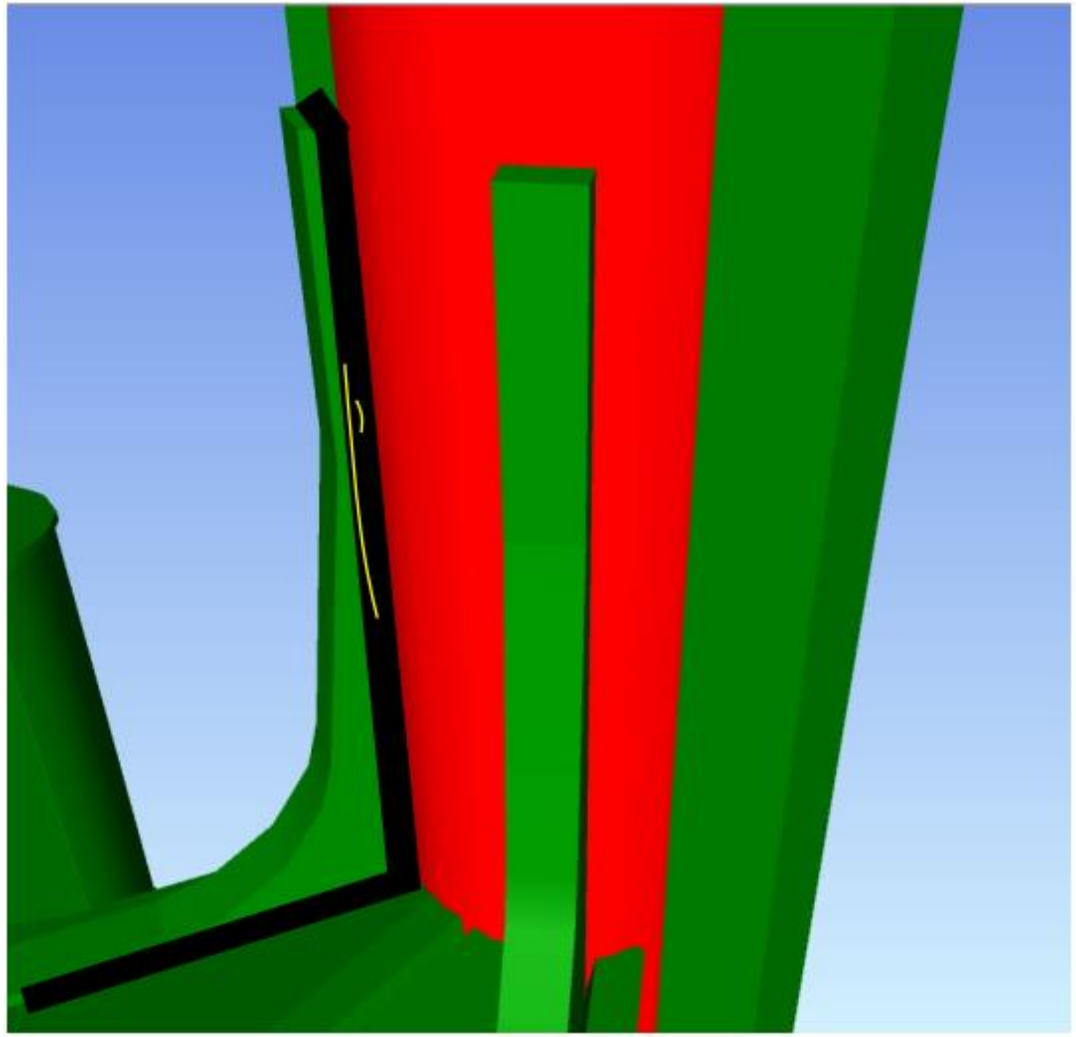
The following areas were 100% UT inspected



& the following area 100% ET inspected



Additional findings in drydock



Intrepid – Transverse cracks

The UT inspection for transverse cracks revealed a number of subsurface transverse cracks in the vertical chord to spudcan welds.

Repair scope

The repair work included the following areas:

- All surface breaking cracks removed by gauging and re-welded.
- All external chord to spudcan welds including backet plate both sides removed by gauging and re-welded.
- Internal chord to spudcan welds in 12 locations (out of 18) removed by gauging and re-welded
- Topplate to bulkhead weld replaced over approx. 1.5 meter at 7 locations (out of 36).
- All gauging and welding work performed with a pre-heat temperature of 150°C. After completion of the welding work the area was heat treated with a temperature of 250°C for 48 hours.

LEG 1
B-A

DNV Høvik involvement

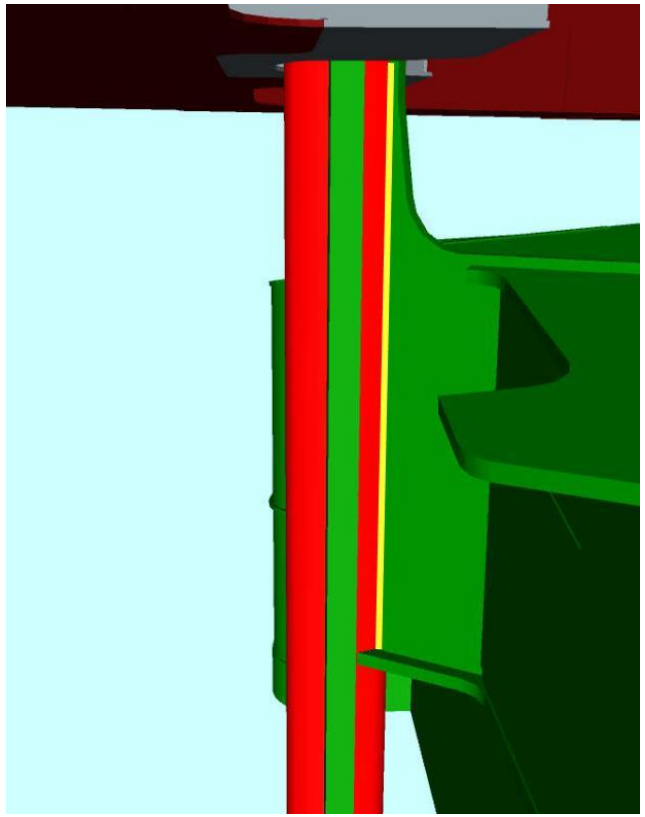
Close communication with DNV Høvik from day one the defects were found during the UWILD.

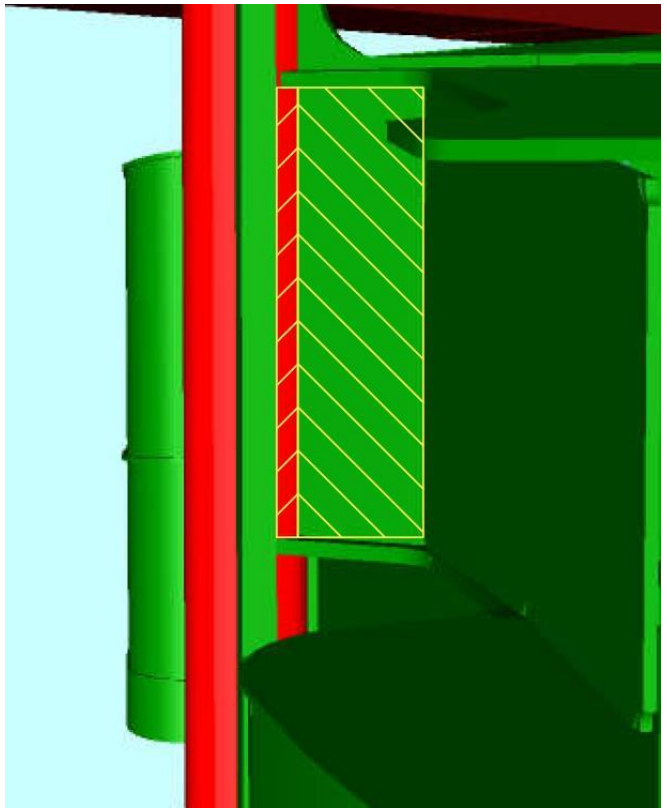
- Failure analysis/mechanism
- Extend and type of additional inspection work
- Strength verification of various areas
- Fracture mechanics
- Coating condition
- Anode protection/CP simulations
- Repair scope
- Extensive involvement on repair site
- Future inspection program

Intrepid – Planned future/follow-up inspection

The following inspection program have been agreed with DNV:

1) Visual inspection of the vertical external chord to spudcan weld including both side of the knee plate. All legs/all chords. Yearly.
2) Inspection for any coating breakdown in the chord to spudcan weld area. All legs/all chords. Yearly.
3) PAUT inspection of the vertical external chord to spudcan weld. Total 6 locations. 2.5 yearly (UWILD/SPS).





The experienced cracking problem is service related propagation of possible fabrication related flaws and defects.

The crack positions, paths and appearances indicate that

the welding process is the "*provider*" (root cause)

hydrogen uptake is the "*trigger*", (cathodic protection)

structural stress is the "*driver*". (wave, sea current, wind, gravitation load