Failure of Cu Cooling of the RE+1/3 /04

Possible causes before access

Erosion in bends

Stress corrosion cracking in union and bent zones

Fatigue ( low cycle) in the bent areas

Zinc removal of the brass union by demin water. Did we use brass resistant to Dezincification eg CW602N (CZ132),

Excess tightening leading to final failure as another parameter works over time against the union integrity

RE1 chambers had copper cooling transfer plates soldered over a hot plate(method shown but really?) to the Cu dia 8 pipe unlike the Re2 &3 which had the plates brazed to the Cu pipe.

Hydrogen embrittlement ?

Microbiological contamination, Non there should be non due to demin water and radiation levels (?)

Erosion

Page 16 <http://www.fwr.org/copper.pdf>

Do we have vibration in the RE cooling pipes ? In the thermal barriers around the Barrel there was significant noise.

Do we have cavitationj.

Corrosion from external contact with other metals ?

Loose nuts/union or lock nut on chamber PP. Why do things become loose ?

 Quot e below is from ;

The Smithsonian/NASA Astrophysics Data System

http://adsabs.harvard.edu/abs/2012TRACE...2..223S

It is found that the fatigue strength decreases with the increase of grain diameter. And linear correlation is obtained between the fatigue strength and the reciprocal square root of the grain diameter. The reduction of fatigue strength of brazed part, can be explained successfully by both effects of the grain growth due to brazing and the stress concentration induced by the geometrical change in dimension at the drazed part.

 The Cu pipe is cold drawn not cold rolled ??

Copper shows signs of pre fatigue failure on the surface, see work from 1928

Termed “DISTURBANCE LINES” in above doc.

Quote from , Low-Cycle Fatigue Fracture Phenomenon of Bended Copper Pipes under Internal Pressure. See ref 8

Fatigue fracture phenomenon of bended copper pipes under internal pressure was similar to low-cycle fatigue fracture phenomenon of strain controlled type at stress concentration parts

Full doc on copper pipe leaks

<http://scholar.lib.vt.edu/theses/available/etd-07072006-191236/unrestricted/OwaisEF_Thesis.pdf>

Copper Pipe fatigue

References

1. [http://link.springer.com/article/10.1361%2F154770205X76367#](http://link.springer.com/article/10.1361/154770205X76367)
2. <https://www.jstage.jst.go.jp/article/jsms/61/6/61_550/_pdf>
3. <http://matjournal.org/index.php?mid=jindex&pid=18451&stage=jlist3>
4. <http://www.achrnews.com/articles/118296-the-adaptive-properties-of-copper-piping>
5. <http://www.corrosionlab.com/Failure-Analysis-Studies/30038.corrosion-fatigue-cu-tube.htm>
6. <http://adsabs.harvard.edu/abs/2012TRACE...2..223S>

From 1928

1. <https://www.ideals.illinois.edu/bitstream/handle/2142/4318/engineeringexperv00000i00176.pdf?sequence=3>
2. <http://astp.jst.go.jp/modules/search/index.php?page=DocumentDetail&journalId=0514-5163_61_6_Low-Cycle+Fatigue+Fracture+Phenomenon+of+Bended+Copper+Pipes+under+Internal+Pressure_N%2FA>
3. http://products.asminternational.org/fach/index.do?search=((Copper))%20OR%20((Cu))
4. <http://www.emeraldinsight.com/journals.htm?articleid=17077146&show=pdf>

Brass doc very complete

1. <http://www.copperalliance.org.uk/docs/librariesprovider5/pub-117---the-brasses_whole_web-pdf.pdf?sfvrsn=0>
2. <http://www.fwr.org/copper.pdf>
3. <http://www.copper.com.au/copper/wcms/en/home/plumbing/publications/CDC-TAFE-Plumbing-0824-Lock.pdf>

See page 45-46 for pressure drop inpipes and velocity flow

1. <http://ipnpr.jpl.nasa.gov/progress_report/42-69/69O.PDF>
2. http://ipnpr.jpl.nasa.gov/progress\_report/42-69/69O.PDF

Unions

1. [http://www.ksdistribution.com.sg/ksd/wp-content/uploads/pdfs/ksfc/Parker/Fittings,Materials%20and%20Tubing%20Guide.pdf](http://www.ksdistribution.com.sg/ksd/wp-content/uploads/pdfs/ksfc/Parker/Fittings%2CMaterials%20and%20Tubing%20Guide.pdf)

http://www.ksdistribution.com.sg/ksd/wp-content/uploads/pdfs/ksfc/Parker/Fittings,Materials%20and%20Tubing%20Guide.pdf

Photo from jap paper ref 2

Cracked pipe in the bent area.

Pipe working

1. http://www.g-w.com/pdf/sampchap/9781566379656\_ch03.pdf