Plant Examples of Potential Failure Mechanisms (Not all real)

[1] Gas circulator impeller: 2.25%Cr1Mo heat treated to have high strength, operating at 290^{o}C and speed 3000 rpm. Increased vibration has always been observed during on-load refuelling periods. What are the likely mechanisms if failure occurs during a long period of steady running?

[2] Gas circulator motor, rotor bars: Cu alloy, centrifugal loading, bars retained by 'end rings', into which they are securely braised, gas cooled. No vibration issues. Bars found cracked. Likely mechanism?

[3] Main steam pipe branch on conventional power station, CMV, operating at ~565^{o}C for ~300,000 hours, with a few hundred load cycles (the latter is not really typical of real UK stations).

[4] Main steam pipe butt weld on conventional power station, CMV, operating at ~565^{o}C, 300,000 hours running, regularly two-shifting (hence many thousands of cycles – more typical of UK coal plant).

[5] Terminal weld between main steam pipe and steam chest, CMV, 525^{o}C, 200,000 hours running, pipe-run has a history of previous repairs.

[6] CMn drains pipework beneath the turbines at SZB, <100^{o}C.

[7] DNB superheater penetration under fault conditions such that the penetration-concrete interspace becomes pressurised by escaping steam (see G/A). What mechanism might be of concern as regards potential gas-side failure?

[8] Large diameter pipe branch, CMn, 200^{o}C, occasional known over-pressure well beyond design (but maximum threatened over-pressure has happened before). What is the mechanism of concern?

[9] Cylindrical pressure vessel with hemispherical ends caps, well designed and fabricated, but internally over-pressurised well beyond design.

[10] Cylindrical pressure vessel with torispherical ends caps, well designed and fabricated, but internally over-pressurised well beyond design (tricky one).

[11] DNB diagrid, CMn with electroslag and MMA welds, heavily neutron irradiated in service, subject to impact by a dropped CBMU after a long period off load.

[12] 316ss hoops which retain the coverplates of the reactor pressure vessel internal insulation assemblies in the T2 regions of AGRs, 650^{o}C. Negligible primary loading.

[13] Dump steam system at DNB, passing valve has led to standing water during operation in the horizontal part of the pipe. Pipe is pressurised during start-up and shut-down.

[14] Small bore branch at top of pipe, CMV: hot reheat pipe at 525^{o}C, branch line unlagged and no valve.

[15] The UTJ region of an AGR boiler (junction between 9%Cr1Mo and 316ss) operated for a prolonged period with steam at 160 Barg and ~340^{o}C – which means with no superheat margin.

[16] DNB main steam pipework (316ss), leak elsewhere led to pipe getting wet during an outage.

[17] CW system: carbon steel, containing sea water, protective coating found damaged.

[18] DNB superheater headers, thick section 316H, new weld made to re-attach dome end removed for inspection purposes, 520^{o}C. Accidental omission of PWHT, suspicion about quality of weld prep as regards inadequate removal of previous HAZ.

[19] CW inlet culverts – what are the threats?

[20] LP turbine blades/fixings – what are the threats?

[21] Thick 2.25%Cr1Mo steam chests in two-shifting conventional plant. Multiple cracks found in random orientations on the inside surface, but none penetrated the chest.

[22] HYA/HRA boilers, subject to successive chemical cleans to reduce DP.

[23] Generator rotor on conventional two-shifting plant: tripped on high vibration. Whole rotor section found to contain a >50% crack. Conductor retaining bars found to have play with respect to rotor teeth.

[24] HRA cold reheat system. Observed damage to cladding suggested impact with walkways several inches away. Several bent hanger rods. Passing valves discovered, and postulated to have led to water accumulation off load.

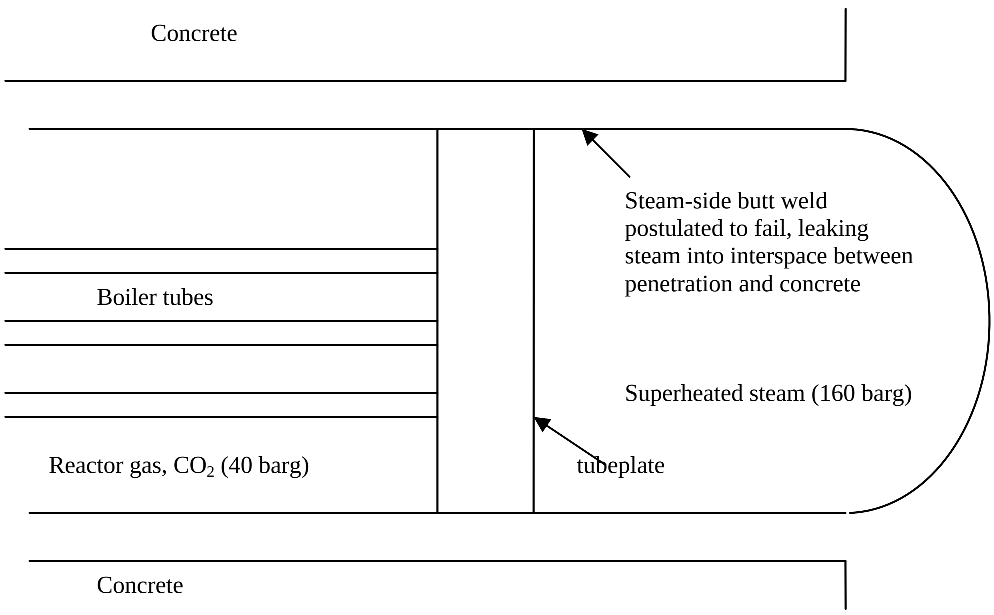
[25] An item which has been assessed and shown to be outside strict shakedown. What are the *two* specific threats?

[26] The HPB/HNB superheater bifurcations.

[27] The cracks found in 2012 on the HYA s/h header tubeplate upper radii, predominantly transgranular and mid-radius. Were not present at an earlier outage. Very large trip transient thermal stresses. Water exiting boiler shows sharp spike in conductivity post-trip.

[28] A 300-series stainless steel casting with relatively high initial delta ferrite content, operating for >20 years at above 600oC. What is the specific threat to integrity under a fault impact event?

DNB Penetration for Qu.[7]



Pick-List of Mechanisms

[A] Brittle fracture

[B] Plastic collapse

[C] Creep rupture

[D] High cycle fatigue

[E] High strain fatigue

[F] Creep-fatigue crack initiation / growth

[G] Reheat cracking

[H] Fretting

[I] Creep crack growth

[J] Fatigue crack growth

[K] Ratchetting

[L] Buckling

[M] Material loss: oxidation(corrosion)

[N] Material loss: FAC (flow accelerated corrosion/erosion-corrosion)

[O] Environmentally assisted cracking (EAC) / Stress-corrosion cracking (SCC)

[P] Corrosion-fatigue / Environmentally assisted fatigue

[Q] Thermal ageing (strictly this is a contributory cause, not a failure mechanism)

[R] Water hammer (strictly this is a loading mechanism, not a failure mechanism)

[S] TTIBC (thermal transient induced bore cracking): Special case of Q+F+I+J

[T] Type IV cracking: Special case of F+I+J

[U] Small bore thermal fatigue condensate reflux cracking (special case of E)

[V] Thermal fatigue: special case of E.

[W] Surface hardening/carburisation cracking / oxidation of sensitised grain boundaries

[X] Intergranular Attack (IGA)

[Y] Crustacean/scyphozoan blockage