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GOVERNMENT OF INDIA
MINISTRY OF POWER

Renewable Integration and Sustainable Energy Initiative (RISE)
Coal Based Flexible Generation Pilot

- **HEP Industry concerns**
- Date: Aug 24-25, 2018.
- Venue: Power Management Institute, NTPC, NOIDA, India
- Presenters: Marvin Cohn, P.E., P.Eng., FASME, Intertek Engineering Consulting, USA

GREENING THE GRID (GTG) PROGRAM
A PARTNERSHIP BETWEEN USAID/INDIA AND GOVERNMENT OF INDIA

AGENDA

1. Tabulation of Concerns
2. Root Causes of Failures
3. Typical Failure Mechanisms
4. Selection of Critical Girth Weldments for NDE

GIRTH WELD IN-SERVICE CREEP CRACKS
(GR P11, P22, AND P91 PIPING SYSTEMS)

List of HEP In-service Creep Cracks

Plant ID	Exam Year	Piping System	Operating Hours	Malfunctioning Support(s)
1	1998	MS	27,000	Y
2	2001	MS	24,000	Y
3	2014	MS	60,000	Y
4	2006	MS	35,000	Unknown
5	2017	MS	~50,000	N
6	2012	MS	53,000	Y
7	2012	HRH	96,000	Y
8	2014	MS	~43,000	N
9	2015	HRH	~90,000	Y
10	2013	MS	33,000	Unknown
11	2004	HP	**147,000**	Y
12	2018	HP	**260,000**	Y
13	1998	MS	122,000	Y
14	2015	MS	260,000	Y
15	1999	MS	158,000	Y

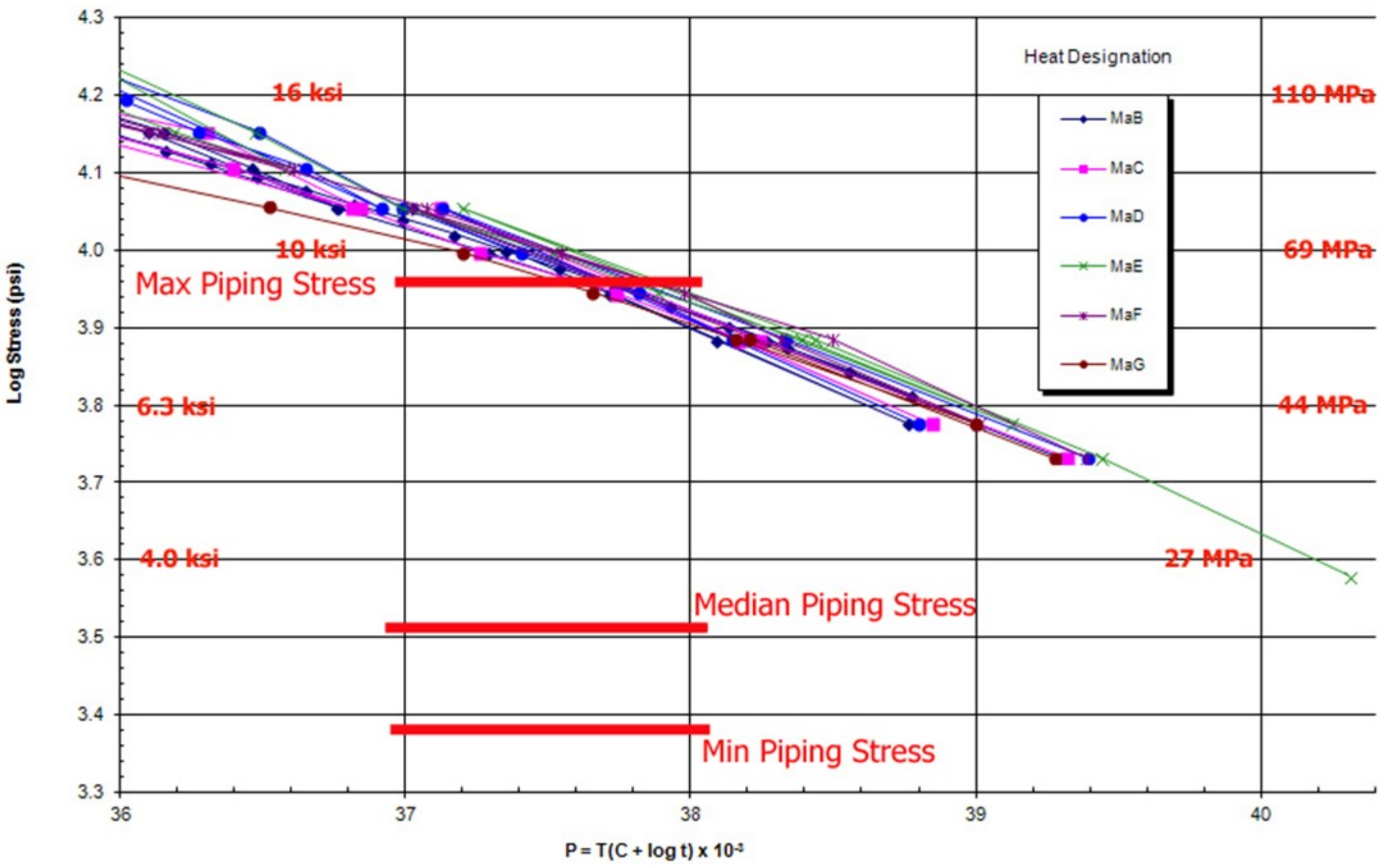
INDUSTRY CONCERNS -1

- Some initial design margins may no longer exist for older plants
- Basis for Code stress allowables in the creep temperature range is an estimation of applicable 100,000 hour material creep rupture properties and some units are operating beyond 300,000 hours
- Many piping systems do not behave as designed
- Gr 91 material chemical composition variations, including trace/tramp elements
- Thin-to-thick transitions and unreinforced branch connections
- Turbine bypass, auxiliary steam, extraction steam, and low point drains
- Dissimilar metal welds and material transitions (in-line component, flow nozzle, thermal weld, and gamma plug)
- Thermal expansion differentials

INDUSTRY CONCERNS -2

- Condensate management (forced-outage practice)
- Combined cycle and cogeneration plants 2X1, 3X1 and various units with dead legs
- Attemperators (spray nozzle), letdown stations, batwing riser supports, and condensate
- Elastic follow-up
- Longitudinal seam welded piping
- Actual operating temperatures/pressures compared to design specifications

STRESS RUPTURE DATA CURVES AND TYPICAL RANGE OF PIPING STRESSES - GR 22 PIPING SYSTEM



PIPING FAILURES - ROOT CAUSE SOURCES

- Design (layout, pipe size, and materials selection)
- Laterals, tees, weldolets (Gr 91 components)
- Fabrication (defects)
- Operation (transients, temperatures, pressures, condensate, mode)
- Maintenance
- Management of change (e.g., material, layout, component)
- Time-dependent degradation of materials

PIPING FAILURES - POSSIBLE FAILURE MECHANISMS

- ***Observed material damage should have a failure analysis and RCA***
- Creep
- Fatigue, creep/fatigue interaction *(flexible operation)*
- Thermal shock, thermal fatigue, thermal ratcheting *(thermal operation*)
- Differential thermal expansion *(thermal operation)*
- Flow-induced or mechanically-induced vibration
- Mechanical damage
- Deformation/overload

CONVENTIONAL APPROACH TO SELECT CRITICAL GIRTH WELDS SUBJECT TO CREEP DAMAGE

- Highest code stresses (S_L and S_E)
- Terminal point welds
- Fitting welds

CONVENTIONAL APPROACH TO SELECT WELDS

- Does not consider field conditions and weldment multiaxial constraints
- Has insufficient synergism among NDE, piping system walkdown, simulation as-found stress analysis, and life consumption results

WHY IS THERE POOR CORRELATION BETWEEN CODE HIGH STRESS LOCATIONS AND CREEP/FATIGUE DAMAGE?

- Field thickness significantly different than specified
- Constant support hangers – nonlinear loads
- Variable spring hangers – significantly different loads
- Improperly functioning hangers (TO, BO, broken)
- Code S_L and S_E stresses do not include the hoop stress
- Creep damage from operating stress
- Time-dependent stress redistribution
- Weldment creep damage properties
- Operating history different than design expectations

HEPLC APPROACH FOR HEP-CREEP AIM PROGRAM

- Empirical evaluation
  - Field measurements and displacements
  - Malfunctioning supports
  - Operating temperatures and pressures
  - Other field anomalies (e.g., interferences, sagging, bowing, bent structural steel, drain line supports)
- Engineering-based evaluation
  - Considers all failure mechanisms
  - Simulation piping stress analyses
  - Multiaxial stresses (3 dimensions)
  - Elastic and inelastic (time dependent) stresses
  - Calibrated life consumption evaluation (where and urgency)

HEPLC PROGRAM FOR GIRTH WELDS SUBJECT TO CREEP DAMAGE

- Hot and cold walkdowns
  - Documented with photographs
- As-design piping stress analysis for base-line information
- As-found piping stress analysis to simulate significant field anomalies
- Elastic and inelastic multiaxial stresses
  - With axial and radial stress redistributions
- Time-dependent weldment creep life consumption evaluations
  - Weldment strength reductions
  - Life fraction analysis
  - Cumulative life consumption
- Remaining lives, reexamination locations, and intervals
  - Evaluation of previous weld repairs and NDE results
  - Evaluation of previous support repairs and WD results

SELECTION OF CRITICAL LOCATIONS
HEP AIM VS. CONVENTIONAL METHODOLOGY
"FEWER LOCATIONS, HIGHER CONFIDENCE"

- Study considered the selection of critical girth weld results of 18 Piping Systems (MS and HRH)
- Unintended high stress welds (e.g., due to malfunctioning pipe supports) were missed using the conventional approach
- The majority of welds selected by the conventional approach had low stresses (with negligible creep damage) – yet they were scheduled to be reexamined multiple times in the future

THANK YOU

Thank you and your support staff for the hospitality and cooperation.