



Process for Revising the MRP Inspection Plan for Upper Head Penetrations

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Topics

- Revision to MRP-75
 - Key changes from MRP-75
 - Combination Baseline Inspections
 - Safety Assessment Process Overview
 - Failure Modes and Effects Analysis
 - Main Evaluations
 - Nozzle Ejection
 - Head Wastage
 - Supporting Evaluations
 - Crack Growth Rates
 - Stress Intensity Factors
- Schedule for Issuing Revised Inspection Plan and Safety Assessment Report

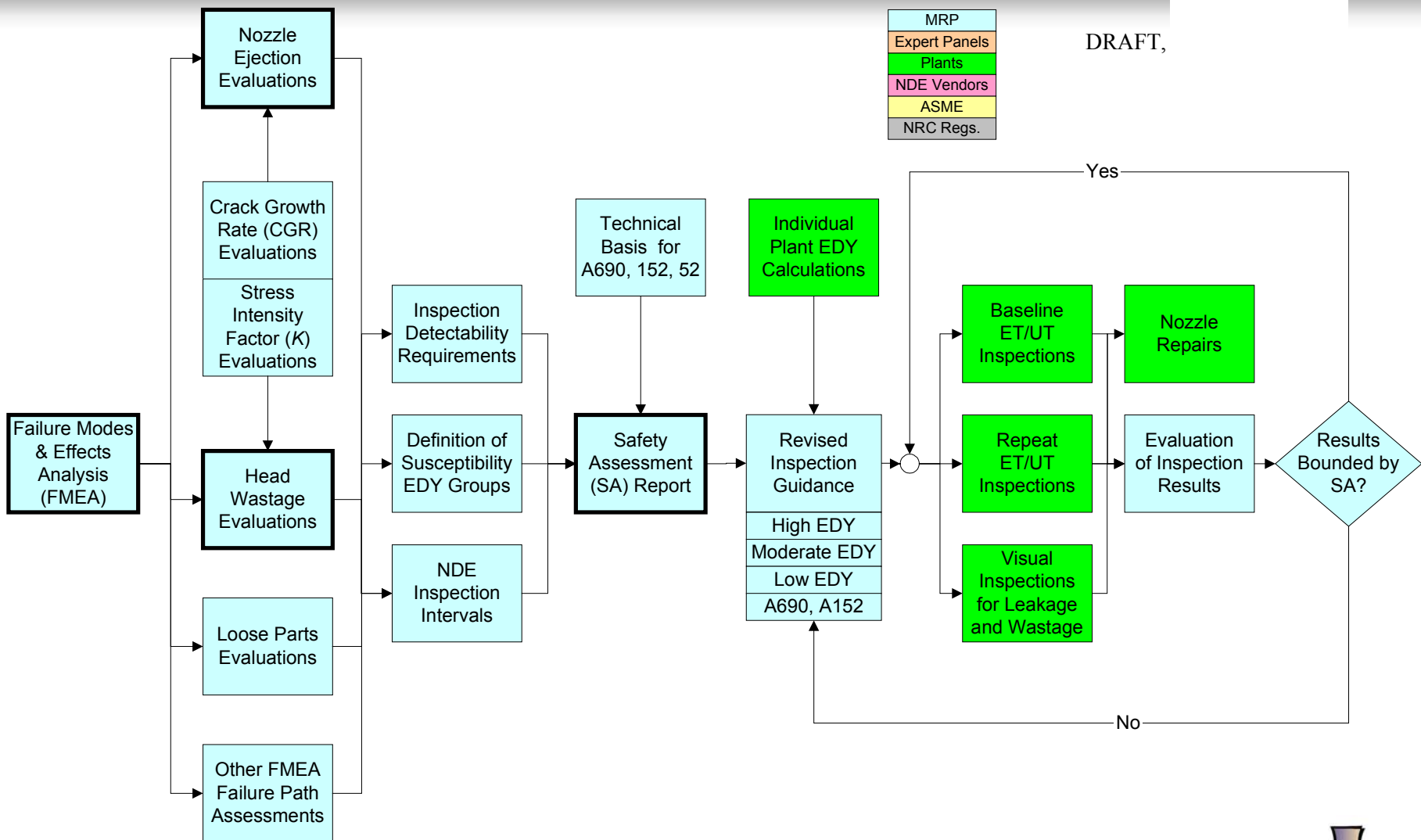
Key Changes from MRP-75

- Implementation of baseline exams employing a combination of techniques
- Proactive rather than reactive approach

Combination Baseline Inspections

- MRP released a letter (November, 2002) to the industry recommending a transition to combination baseline inspections
 - Incorporated fall inspection results
 - Revised MRP-75 reliance on visual inspection
 - Recommended three types of combination inspections
 - UT/BMV, UT/ET, or ET/ET
 - Based the timing of the baseline inspection on susceptibility
- NRC issued order with similar requirements

Overall Process Flowchart



Failure Modes and Effects Analysis: Introduction

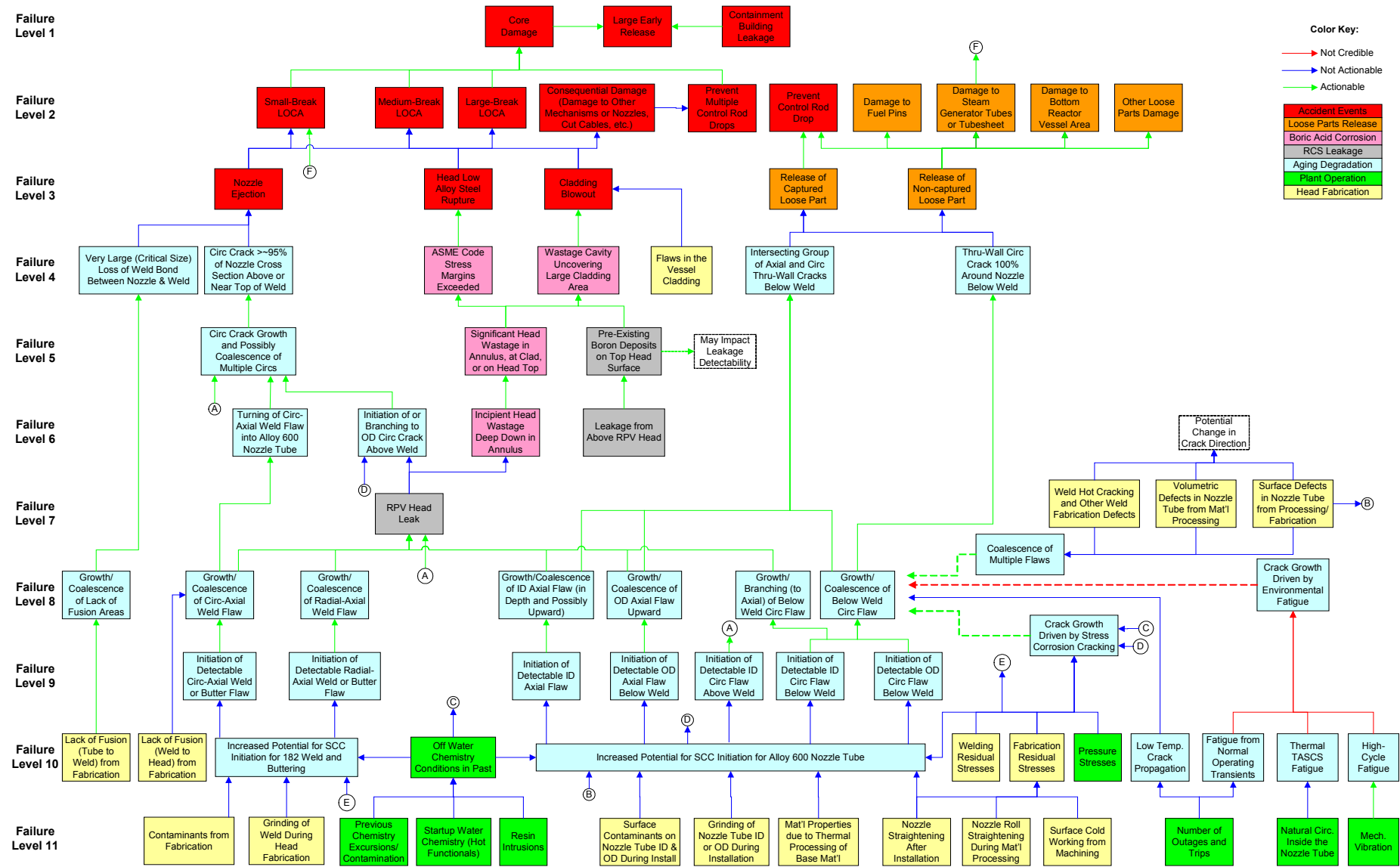
- FMEA is a technique of TQM (Total Quality Management) to ensure product reliability
- Typically, a table of the following characteristics of the possible failure modes is prepared:
 - Cause
 - Effect (consequence)
 - Detectability
 - Frequency of Occurrence
- Relationships among the failure modes are illustrated using a block diagram
- FMEA is a tool that helps anticipate new failure modes

Failure Modes and Effects Analysis: Application to RVH Nozzles

- For RVH penetrations, there are three principal failure modes:
 - Nozzle Ejection Due to Net Section Collapse
 - Cladding Blowout Due to Wastage
 - RCS Damage Due to Loose Parts Generation
- There are several levels in the failure process for these modes:
 - PWSCC initiation (nozzle ID, nozzle OD below weld, weld surface)
 - PWSCC growth (axial and circ in nozzle, axial-radial and circ-axial in weld; weld to nozzle and nozzle to weld; turn from axial to circ)
 - Leakage to annulus (new crack initiation and low-alloy steel wastage)
 - Growth to allowable size / wastage until code allowable stresses are reached
 - Growth to net section collapse or loose parts release / wastage to cladding blowout
 - LOCA and possible consequential damage / loose parts damage
 - Effect on core damage frequency (CDF)

Failure Modes and Effects Analysis: Classification of Failure Conditions

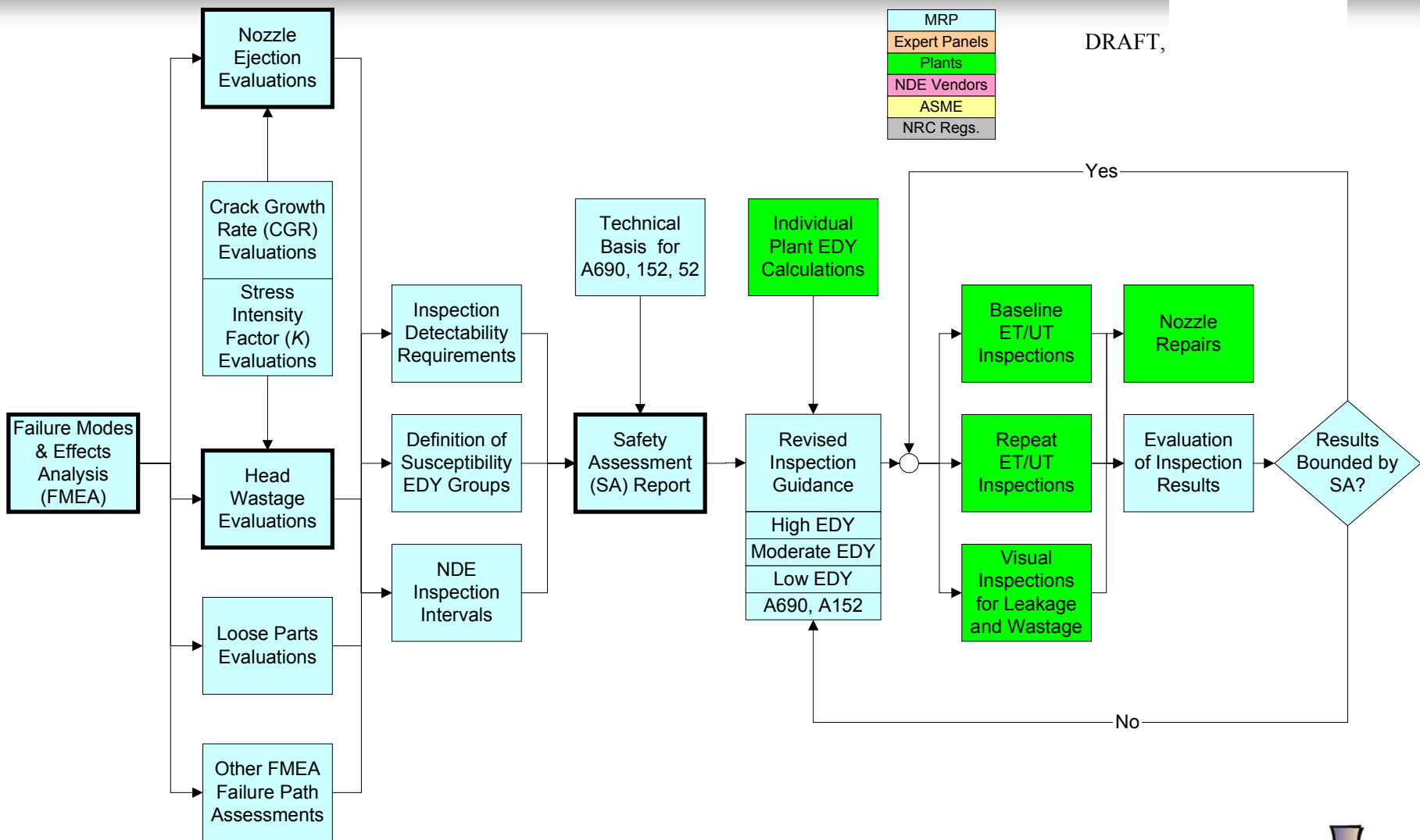
- Each failure condition will be classified as:
 - Not credible,
 - Not actionable, or
 - Actionable
- A classification as “not credible” will require a strong technical argument and thorough documentation with a high threshold
- A classification as “not actionable” requires that adequate protection be provided at a higher level in the failure process
- Conditions classified as “actionable” will be inputs to the probabilistic and deterministic evaluations and will ultimately shape the detectability requirements specified in the inspection plan



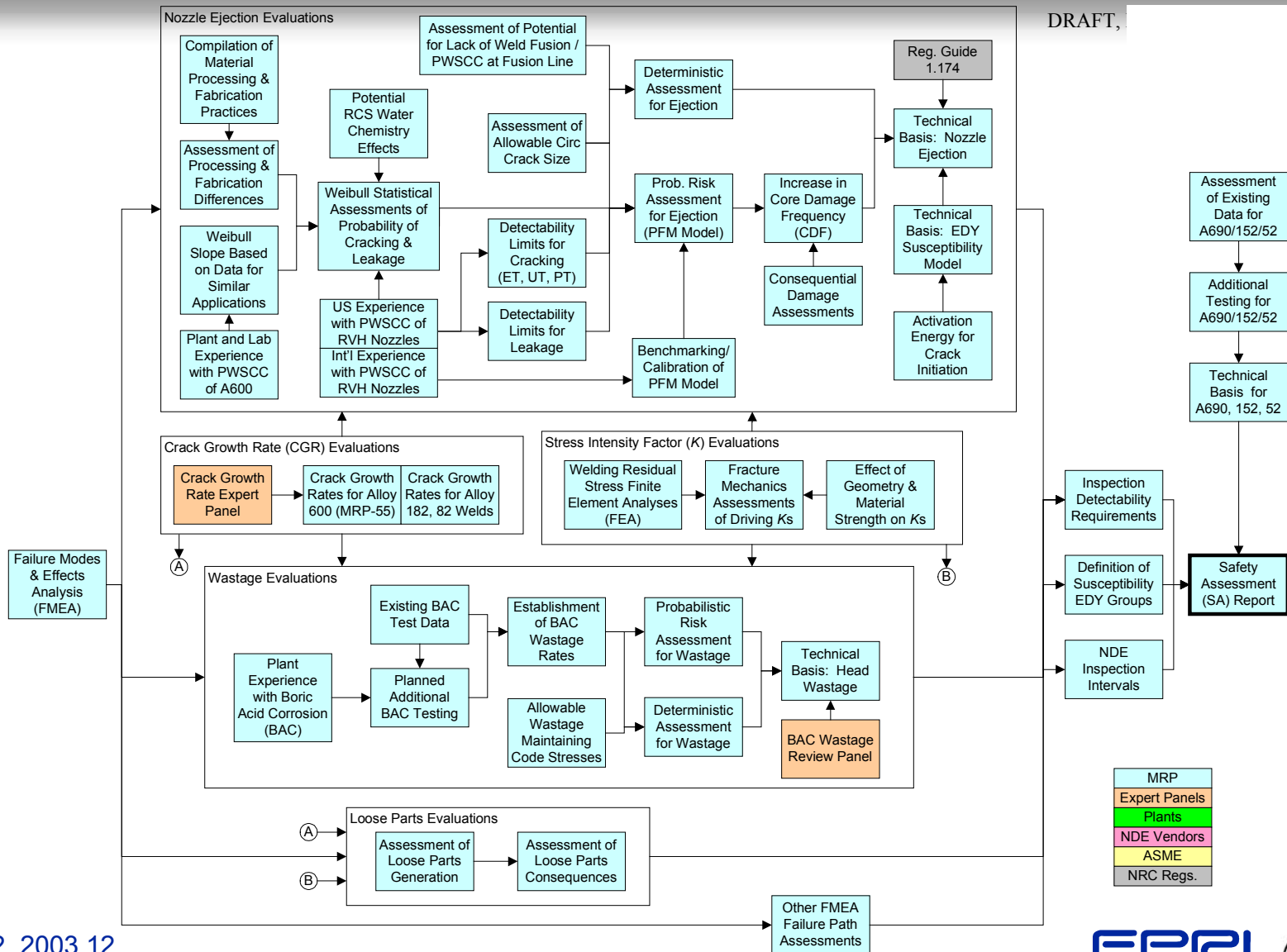
Failure Modes and Effects Analysis: Frequency of Occurrence

- Sources of data for determining frequency of occurrence
 - Weibull reference curves based on the latest inspection results (next presentation)
 - Crack growth rates based on MRP-55 (next presentation)
 - Stress intensity factor calculations (next presentation)
 - Boric Acid Corrosion Testing (previous presentation)
 - Existing LOCA analyses
 - Consequential damage assessments
 - Loose parts damage assessments

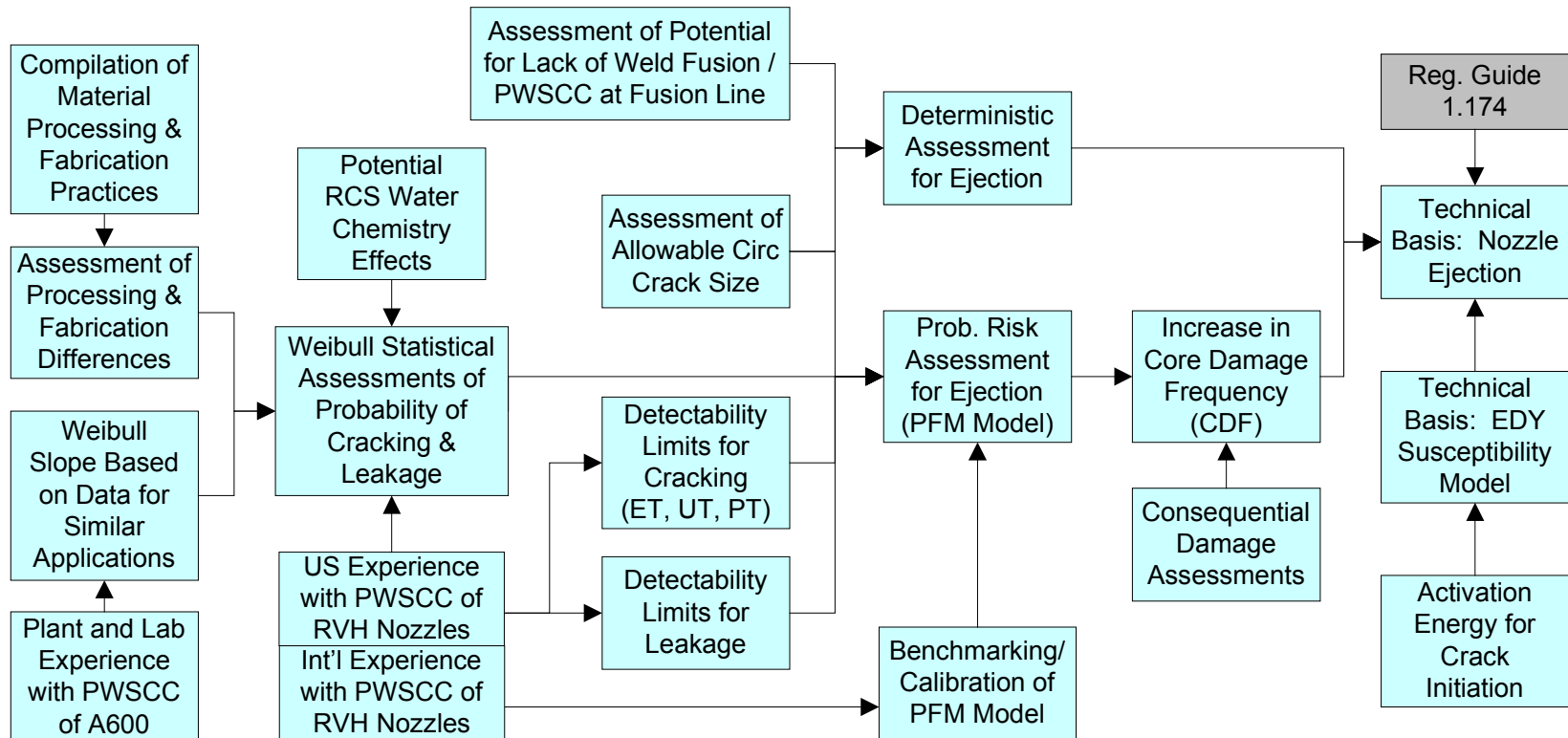
Overall Process Flowchart



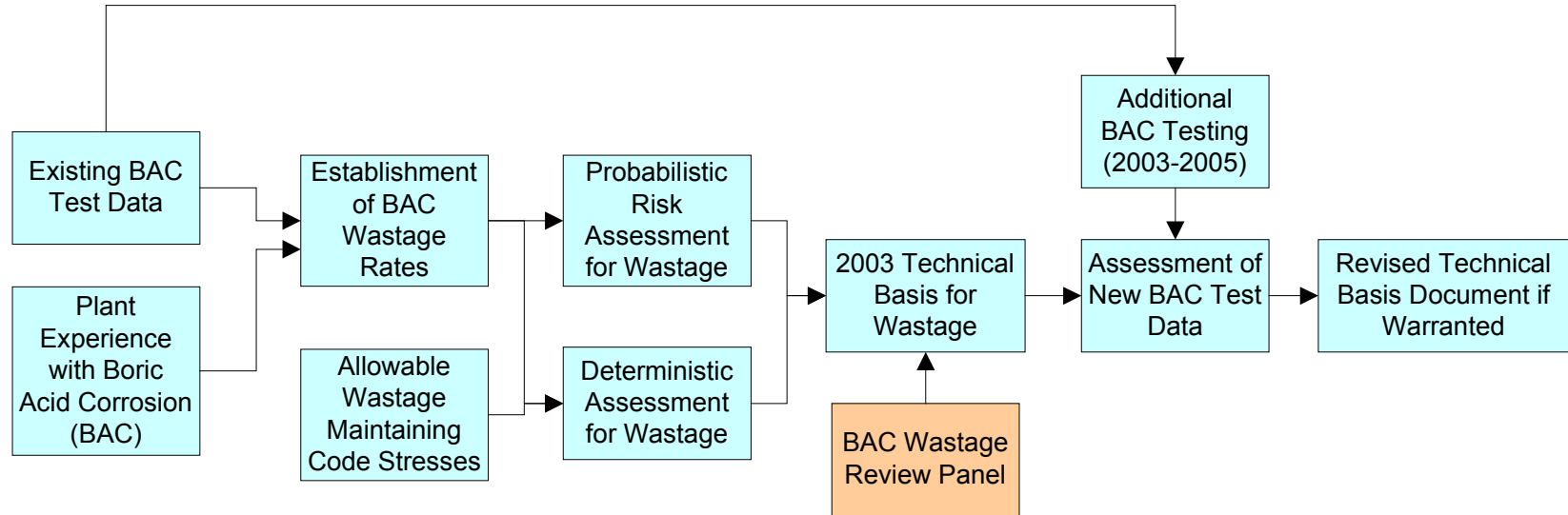
Safety Assessment Process



Main Evaluations: Nozzle Ejection



Main Evaluations: Head Wastage



Supporting Evaluations: Crack Growth Rates

- The MRP report addressing the crack growth rates (CGRs) of Alloy 600 base metal (MRP-55) was formally submitted to the NRC in September 2002
- The NRC issued a new flaw evaluation guideline (letter to NEI on 4/11/2003) which used the MRP-55 crack growth rate
- PWSCC CGR data for 182/82 contains data from the US and results generated overseas (France, Sweden, Japan)
- A report addressing the weld metal will be produced after data is evaluated

Supporting Evaluations: Stress Intensity Factors

- Stress intensity factor calculations have been completed for several CRDM nozzle geometries
- Comparison with the results produced by the NRC contractor have shown good agreement for same crack geometries
- More conservative stress intensity factors used in current model to address envelope stress distribution above J-groove weld
- Additional work is being performed to evaluate the effect of weld geometry on the stress intensity factors
- The stress intensity factors are a secondary influence behind the crack growth rates on the probability of nozzle ejection

Safety Assessment Process: Key Points

- The MRP approach has transitioned to ensuring safety through “combination” inspections at all plants with:
 - The timing for the baseline inspection and the re-inspection interval based on the technical evaluations
 - More frequent bare metal visual (BMV) inspections providing backup to the program of periodic combination inspections

Safety Assessment Process: Key Points – cont'd

- Proactive identification of possible failure modes
 - Employs a structured approach – FMEA
 - Anticipate possibility of failure paths not yet observed in field
 - Direct subsequent technical evaluations in SA
 - Identify inspection detectability requirements
 - Ensure robust defense for all credible failure paths

Safety Assessment Process: Key Points – cont'd

- Calculations show that non-visual inspections do not have to be performed every refueling outage to ensure safety across the fleet
 - Extremely low probability of nozzle ejection and significant wastage
 - Extremely small consequential increase in core damage frequency ($<10^{-6}$ per reactor year), consistent with NRC Reg. Guide 1.174

Safety Assessment Process: Deliverables

- A comprehensive safety assessment (SA) report will form the basis for a revised MRP inspection plan
 - The Safety Assessment report will:
 - Begin with FMEA
 - Include the analysis tools previously developed and described in MRP-75
 - As appropriate, the SA report will reference other reports (e.g., the MRP report on crack growth rates of Alloy 600—MRP-55)
 - Demonstrate safety of operation based on knowledge of hardware condition
- The revised MRP inspection plan will be formed on the basis of the Safety Assessment report
 - Defines inspection requirements necessary to establish hardware condition relative to SA requirements

Schedule Considerations

- Some calculations remain to be revised and extended, but much of the material to be incorporated into the SA report has already been completed in support of MRP-75
- Data developed subsequent to the initial release of the SA report will be evaluated for consistency with the SA evaluations once such data become available
 - BAC Testing & NA2 Destructive Exam results
- Final submittal expected Spring 2004
 - The MRP will be prepared to discuss a draft of the SA and the revised inspection plan in Fall 2003
 - In the meantime, technical discussions with the NRC staff will continue