Ageing Management Programme and In-service Inspection In Indian PHWRs

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AGEING MANAGEMENT

- ***The engineering, operations and maintenance actions to control ageing degradation and wear out of systems, structures or components within acceptable limits.***
- ***Systems, structures, components (SSC) important to safety are covered under aging management.***
- ***The ageing management program for PHWR in INDIA is based on AERB-SG-O14.***
- ***It includes SSC of Mechanical, Civil, Electrical & Instrumentation .***

AGEING MANAGEMENT

- **The license to Nuclear Power Plants (NPPs) is issued by the Regulatory Body after satisfactory commissioning of the NPPs.**
- **During the process of this licensing all aspects important to safety are assessed at various stages of NPPs.**

AGEING MANAGEMENT

- **Within the operating license, Regulatory Body grants initial authorization for a specified period which may range from five to ten years and renewal of authorization for further specified periods after assessment of periodic safety review.**

AGEING MANAGEMENT

- **For renewal of authorization , comprehensive safety review of plants is required considering the cumulative effects of plant ageing and irradiation damage , results of In-service inspection , system modifications, operational feedback & status of performance of safety system etc.**

AGEING MANAGEMENT

- **This process of safety review for renewal of authorization is carried out several times periodically during the design life of the NPPs. This comprehensive safety review is termed as periodic safety review (PSR).**

AGEING MANAGEMENT

The objective of PSR is to assure that:

- **The NPP as a whole continues to be capable of safe operation at all power levels .**
- **All structures, systems & components important to safety of the NPP , have not shown undue signs of deterioration and are capable of performing their intended function.**

AGEING MANAGEMENT

- **The plant is safe as judged by current safety standards and practices and adequate arrangements are in place to maintain safety.**
- **The NPP has operated in a safe manner during the reporting period and continued operation of the NPP till the next periodic review and renewal of authorization would not pose undue risk to the plant, personnel , public & the environment.**

AGEING MANAGEMENT

- **The safety factor which considered in the conduct of PSR includes amongst other things:**

  Actual physical condition of NPP.

  Safety analysis,Equipment Qualification.

  Management of ageing.

AGEING MANAGEMENT

- **Ageing management programme of Indian PHWR is continuously monitored by Regulatory Body through this PSR.**
- **Ageing management programme of Indian PHWR is based on effective maintenance, surveillance and In-service inspection of system, structure & components and systematic & comprehensive approach of plant life management and plant life extension program.**

AGEING MANAGEMENT

- **Maintenance, surveillance and In-service inspection have a common objective to ensure that the plant is operated in accordance with the the design intent and within the operational limits and conditions.**
- **Maintenance, surveillance and In-service inspection all are sub-set of ageing management programme.**

AGEING MANAGEMENT

- **Earlier perception was that once component is designed and put to use it will last for the designed life.**
- **However, experience has shown that some have failed even before design life is over, whereas some could be used beyond their design life. The components which have shown problem before their design life are:**
- **Pressure Tubes, Feeders & SG tubes.**

AGEING MANAGEMENT

- ***Following are the major Mechanical system covered under ageing management programme.***

- ***Primary heat transport system.***
- ***Reactor components.***
- ***Moderator system.***
- ***Reactor Auxiliary.***
- ***Fueling machine & component.***
- ***Secondary cycle piping.***

AGEING MANAGEMENT

- **Following are the major electrical system covered under ageing management programme.**
- **Auxiliary transformer.**
- **415 Volts, switchgear & MCC**
- **MG sets.**
- **Station Batteries.**
- **DG sets.**
- **Class II, III Relays.**
- **EMTR**

Ageing management programme of Auxiliary transformer (Class III & IV).

- **The basic degradation mechanisms are : Thermal ageing , Insulation degradation, oil degradation & Electrical stress.**
- **Monitoring methods are : Routine monitoring of current, voltage & frequency, winding oil temperature, IR measurement, internal examination.**
- **Monitoring on regular basis is done.**

AGEING MANAGEMENT

Following are the major Civil Structures covered under ageing management programme.

- **Reactor Buildings, Service Building & Turbine Buildings.**
- **Supplementary control room building.**
- **Ventilation stack , PHT purification building.**
- **D2O upgrading plant, CW Pump house.**
- **NDCT , IDCT & Waste Management Plant.**

AGEING MANAGEMENT

Following are the major C & I systems covered under ageing management programme.

- **Reactor protective system.**
- **primary shut down system.**
- **Secondary shut-down system.**
- **ALPAS.**
- **ECCS.**
- **Containment system.**

AGEING MANAGEMENT

- ***Ageing management of the majority of the Mechanical systems are covered under the scope of In-service Inspection.***
- ***Calandria and Endshields see low pressure & low temperature and as a result operate under low stresses. These are made up of SS-304 L . With this and maintenance of close chemistry, no deterioration is anticipated and hence ISI is not envisaged .***

Ageing management programme of 415 V switchgear

- ***The basic degradation mechanisms are : Mechanical failure, insulation degradation , thermal ageing & close/Trip coil failure.***
- ***Regular PM & condition monitoring is being done.***
- ***Monitoring schedule is as per plant Technical specification.***
- ***Thermography using infra red cameras to map the surface temperature are also being planned.***

Ageing management programme of Station Batteries

- ***The basic degradation mechanisms are : Thermal ageing & under/over voltage charge.***
- ***Monitoring methods are: measurement of charging current, cell voltage & electrolyte temperature. Battery discharge test as per technical specification.***
- ***Monitoring schedule is as per plant Technical specification.***

Ageing management programme of DGs

- **The basic degradation mechanisms are : Thermal ageing, high vibration & insulation degradation.**
- **Monitoring methods are: measurement of current, voltage & frequency . IR & tan delta of winding, vibration monitoring.**
- **Monitoring schedule is per plant Technical specification.**

Ageing management programme of Power/control cables.

- **The basic degradation mechanisms are : Thermal ageing, insulation degradation.**
- **Monitoring methods are: measurement of current, voltage & frequency . IR measurement**
- **Monitoring schedule is as per plant Technical specification.**
- **Residual life assessment of the cables are being planned. Radiation ageing assessment is also being planned.**

Ageing management programme of Ion chambers.

- **The basic degradation mechanisms are : Leakage of electrolytic capacitors and random failure of other components.**
- **Monitoring methods are: Continuos monitoring.**
- **Monitoring schedule is as per plant Technical specification.**

Ageing management programme of Relays of PSS /ECCS/Protective System.

- **The basic degradation mechanisms are : Increase in contact resistance , opening of the contacts & coil**
- **Monitoring methods are: Testing as per technical specification.**
- **Monitoring schedule is as per plant Technical specification.**
- **Residual life estimation by conducting test at elevated temperature .**

Ageing management programme of ALPAS valve & actuators.

- **The basic degradation mechanisms are : Erosion, corrosion , wear, mechanical stucking, Puncturing of actuator diaphragm.**
- **Monitoring methods are: visual examination of internal surface of valve casing, PM checks.**
- **Monitoring schedule is as per plant Technical specification.**
- **Diaphragm replacement as per PM schedule.**
- **Residual life estimation of "o" rings and radiation ageing is being done.**

Ageing management programme of Civil structures.

- **Ageing management programme for Civil buildings and structures is prepared as per AERB safety Guide AERB/SG/O-14**
- **Maintenance Manual for routine maintenance of buildings and structures is prepared as per AERB Safety Manual AERB/SM /CSE –1**
- **ISI Procedure for Civil buildings and structures is prepared as per AERB Safety Manual AERB/SM /CSE –2**
- **All routine maintenance is carried out as per approved procedures.**

Ageing management programme of Civil Structures.

- **The basic degradation mechanisms/ ageing effect identified are: Corrosion of pre-stressing steel & reinforcement. Carbonation , leaching, chemical attack, fatigue & vibration caused by equipment and cracking & spalling of concrete.**
- **Monitoring methods are: Visual examination done annually. Non Destructive Testing wherever required based on visual examination and In-Service leakage rate test is done at 1/3rd design pressure once in every two years. ISI done as per approved plan.**
- **Monitoring schedule is as per plant Technical Specification and ISI schedule for Civil Structures.**

AGEING MANAGEMENT

- **During EMCCR Campaign , all the pressure tubes are being replaced with new one. This has been done for earlier generation plant such as RAPS-2, MAPS-2 and currently being done for MAPS-1.**
- **During EMCCR, specific systems, structures & components refurbishment is done.**

IN-SERVICE INSPECTION

- ***MANDATORY INSPECTION OF COMPONENTS CARRIED OUT AT INTERVALS AFTER THE START-UP OF A PLANT .***

Evolution of In-service inspection program for PHWR in India is based on the following codes/guides/standards:

- **AERB-SG-O2 .**
- **CAN-CSA-N285.4-94 , Canadian standard for periodic inspection of CANDU NPP components.**
- **ASME section XI.**
- **IAEA safety guide No.NS-G-2.6, Maintenance , surveillance and In-service Inspection in NPPs**

The In-service inspection programme adopted at Indian Nuclear power plant is specific to each plant and include information about:

- **Selection of system and component subject to inspection.**
- **Categorization of the components for inspection.**
- **Selection of inspection methods and procedure.**
- **Selection, location and extent of inspection areas.**
- **Interval of inspection.**
- **Interpretation of In-service Inspection results followed by Codal analysis.**

ISI Interval

- **First ISI interval - 05 Yrs.**
- **Subsequent ISI- 10 Yrs.**
- **Actual ISI interval may be changed based on operational experience and results of previous ISI campaign.**

IN-SERVICE INSPECTION

- **NPCIL prepares a plant specific ISI programme document , which is implemented after review and approval by Regulatory Body.**
- **Station specific ISI document is reviewed and revised every 05 years in consultation with Regulatory Body .**

System subjected to Inspections:

- **The Reactor coolant pressure boundary and other systems whose failure may results in significant release of radioactive substances.**
- **Systems essential for the safe reactor shutdown or the safe cooling of nuclear fuel or both in the event of process system failure.**
- **Other system and components , the failure or dislodgment of which may jeopardize the integrity of the systems in items mentioned above.**

Categorization of the systems/components for ISI.

- The requirements of inspection , inspection areas and degree of examination are determined based on the matrix consisting of stress intensity ratio and fatigue usage factor based on the size of failure.
- Based on above criteria systems/components are categorized as category A, B, C1 & C2 as per AERB-SG-O2 & CAN-CSA-N285.4-94 , Canadian standard for periodic inspection of CANDU NPP components.

NDE technique used in ISI are:

- **Ultrasonic Examination. (Volumetric Examination)**
- **Eddy current Examination.(Volumetric examination as far as SG & HX tubes are concerned)**
- **Liquid Penetrant Examination. (Surface examination)**
- **Magnetic particle Examination. (Surface Examination)**
- **Leak Testing.**
- **Visual examination.**

Systems selected for ISI :

- **PHT System.(Including PHT relief system) .**
- **Shutdown system.**
- **ECCS system.**
- **Primary shutdown system.**
- **Secondary shutdown system.**
- **ALPAS.**
- **Moderator system.**
- **Main steam lines(Inside RB) , Feed water system (Inside RB) & Auxiliary feed water system (Inside & outside RB)**
- **Process water system.**
- **AGS.**

Components subjected for ISI (In case of PHWR)

- Pressure Tubes.
- Pressure boundary portion of safety system piping.
- PHT system Feeders.
- Steam Generators/Heat Exchangers.
- Fueling machine components.
- PCP, PCP flywheel, S/D pumps & ABFP
- PHT system boundary valves, SSS shut-off valves, MSL, FW & AFW system valves.
- Piping / equipment supports.

In-service inspection requirements for Pressure Tubes:

- **Pressure tubes , which contain the fuel bundles , are the most critical component in the core and form a vital part of reactor coolant pressure boundary and subjected to various degradation mechanisms such as:**

1 **Delayed hydride cracking.**

2 **Irradiation enhanced deformations.**

3 **Changes in pressure tube material properties**

- **The basic philosophy of ISI of Pressure tube is to ensure the structural integrity and to demonstrate LBB .**

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Extent of In-service Inspection of Pressure tube:

- **Volumetric examination and Wall thickness measurement (at 6 o' clock) of pressure tubes by Ultrasonic method.**
- **Inner surface scanning by Eddy current testing.**
- **Garter spring positions by Eddy current testing.**
- **Gap between calandria tube and pressure tube by eddy current testing and sag profile of pressure tubes.**
- **Rolled joint inspection .(at PSI stage)**
- **Hydrogen evaluation from scrape sample.**
- **Special techniques such that determining calandria tube/Pressure tube by NIVDT.**

ISI Experience : Pressure Tube Inspection

- **An elaborate pre-service inspection , base line inspection & Inservice inspection program exists for pressure tube to assess the effects of degradation and therefore establish the safety of the reactor.**

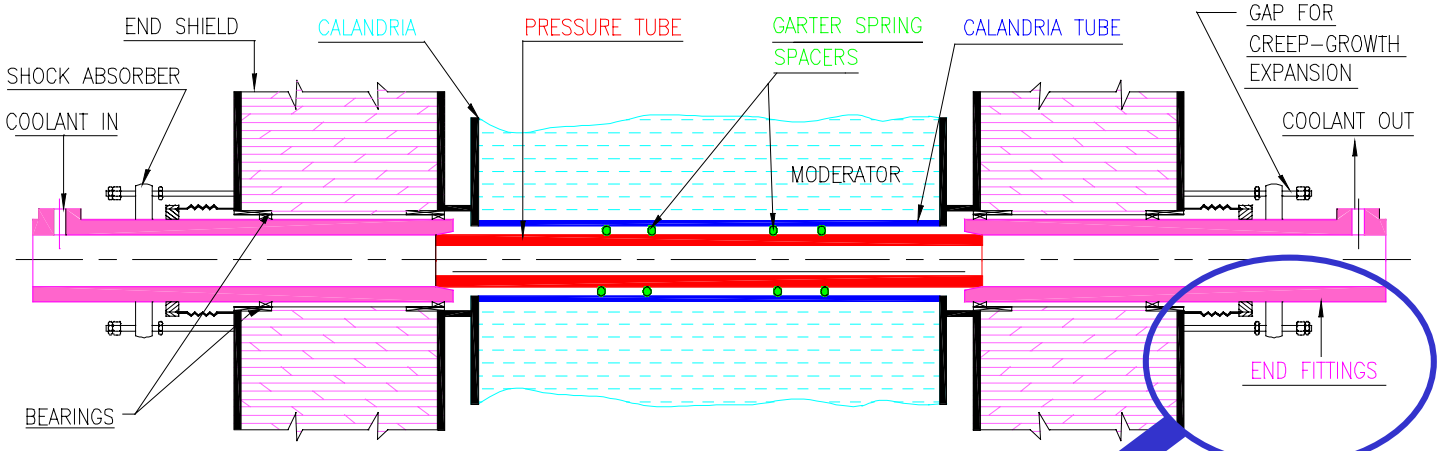
ISI Experience : Pressure Tube Inspection

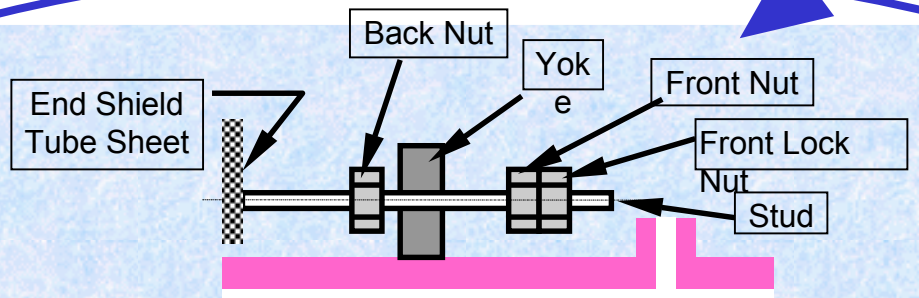
- **Special manipulator are being used to detect the deterioration(s) in the pressure tubes.**
- **BARC has developed BARCIS, which addresses all the task using an automated remote inspection system.**
- **BARCIS is capable of examining of pressure tubes without ice-plugging of feeders.**
- **It has eddy current probes for sensing garter spring position and orientation as well as measuring gap between the two concentric tubes.**

ISI Experience : Pressure Tube Inspection

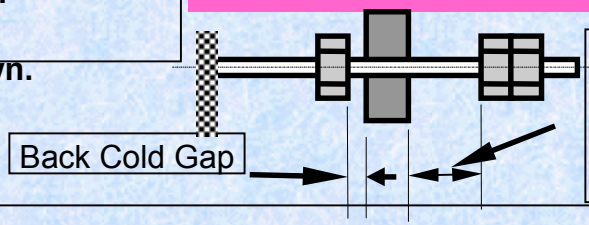
- **Ultrasonic probes are used to measure the pressure tube wall thickness and for flaw detection in axial & circumferential directions.**
- **The results of each ISI campaign are evaluated to assess the fitness for service criteria.**

PRESSURE TUBE



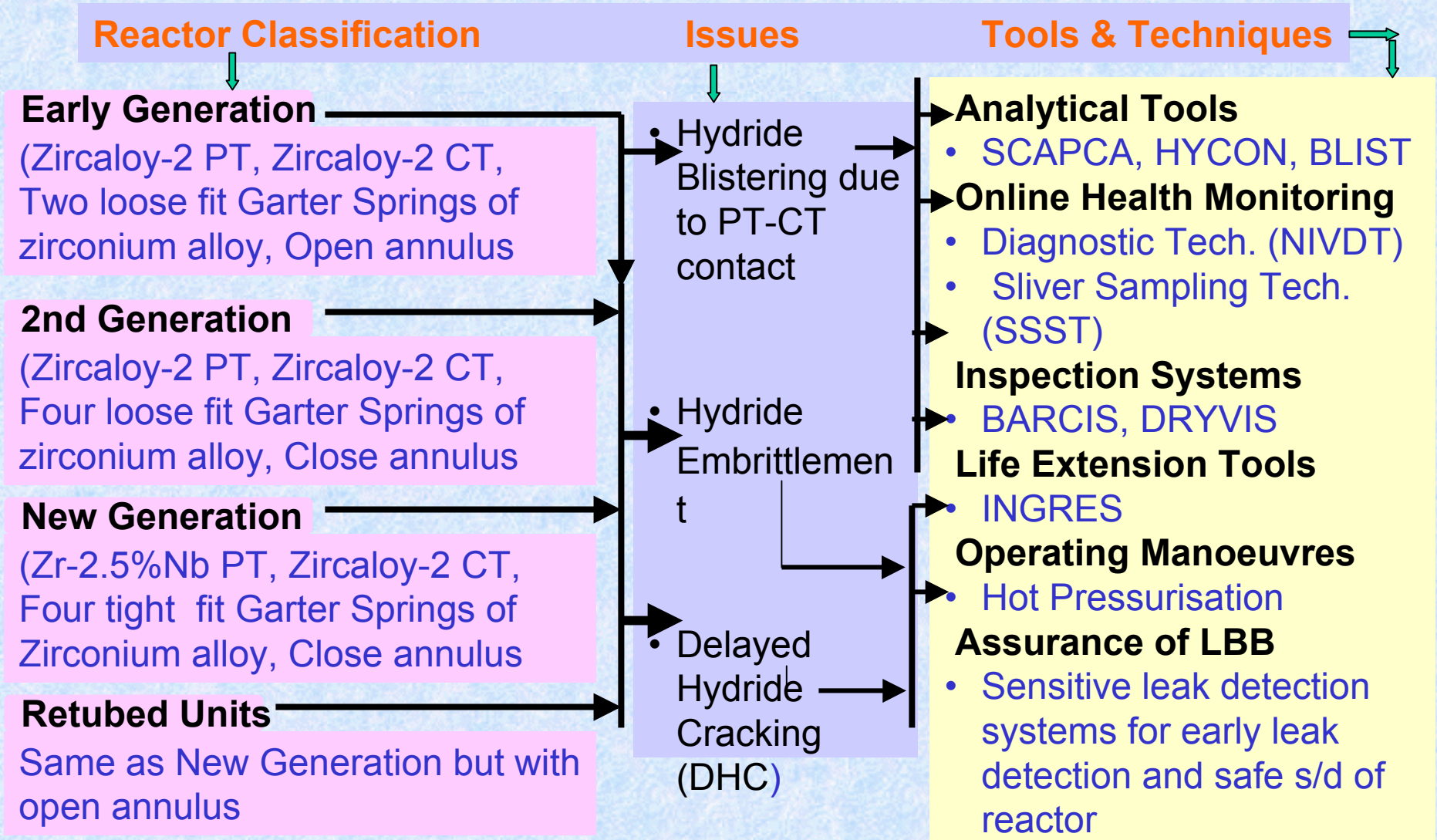


•**Floating End.**
• **Reactor Cold/Shutdown.**



Reduction in Front Cold Gap arrests axial movement of PT during operation

A BROAD RANGE OF TOOLS AND TECHNIQUES ARE CURRENTLY IN USE FOR PRESSURE TUBE LIFE MANAGEMENT



LIFE MANAGEMENT STRATEGY-1

Un-Inspected Core

1

Analysis using codes for hydrogen estimation and blister growth time estimation assuming worst case scenario

2

Arrangement of channels in ascending order of blister growth time

3

Diagnosis of channels by NIVDT to find out probable contacting channels

4

Identification of common set of channels from lists of step-2 & step-3

5

ISI of the channels identified in step-4 + some additional channels

6

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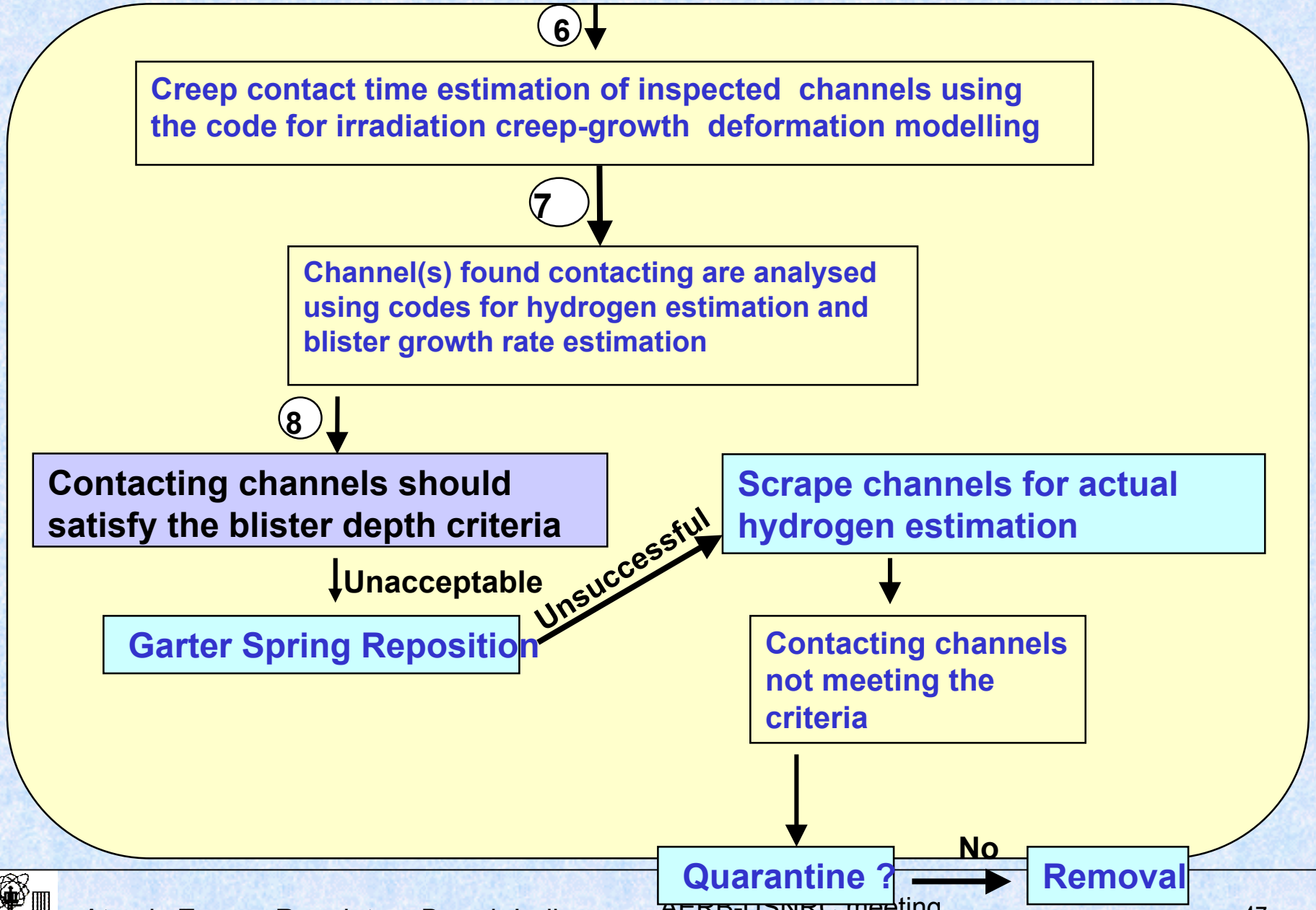
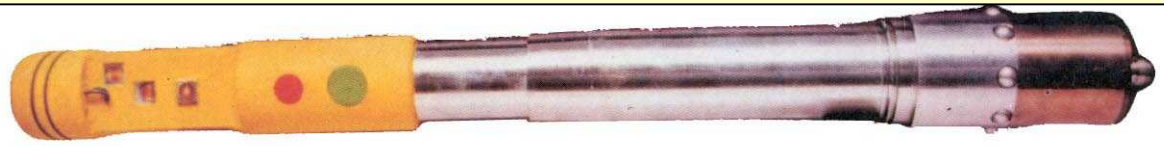
LIFE MANAGEMENT STRATEGY-2



BARC INSPECTION SYSTEM(BARCIS)

- Used for ISI of coolant channels
- Uses a UT and eddy current sensors for detection of any flaw,assessment of wall thickness of PT, detection of garter springs and measurement of PT-CT gap.
- Has undergone a number of modifications over the years.



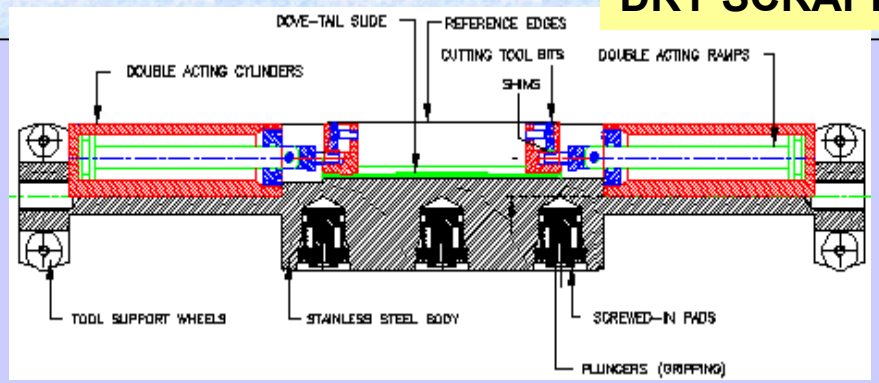
INSPECTION AND DIAGNOSTIC TECHNIQUES -SSST

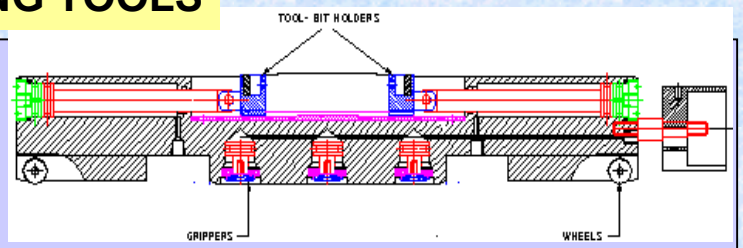
- **The Sliver Sample Scraping Tool (SSST)** developed for obtaining in-situ scrape samples from dry pressure tube of operating PHWR for measurement of hydrogen concentration.
- The system was used successfully for the first time April 1998 to take samples from two pressure tubes of MAPS-1 reactor.
- Later, it was modified to reduce man-rem consumption and down time of reactor by incorporating remotised handling operation.
- The new version of the tool is developed called WEST (Wet Scraping Tool)
- The WEST had been used for taking 36 samples from MAPS-1 reactor, 106 samples from RAPS-1 and 36 samples form NAPS-1

Sliver Sample Scraping Tool

SLIVER SAMPLE SCRAPING TOOL: SCHEMATIC VIEW

DRY SCRAPING TOOLS

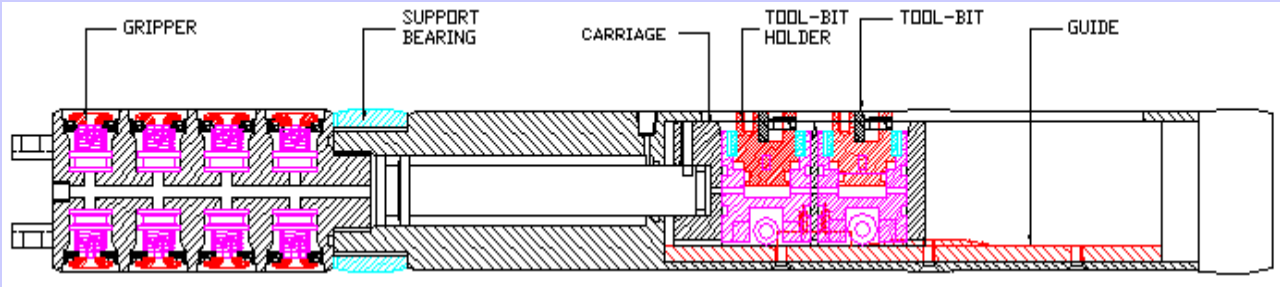




SSST-1 (OPTIMISED)

SSST-1 (MODIFIED)

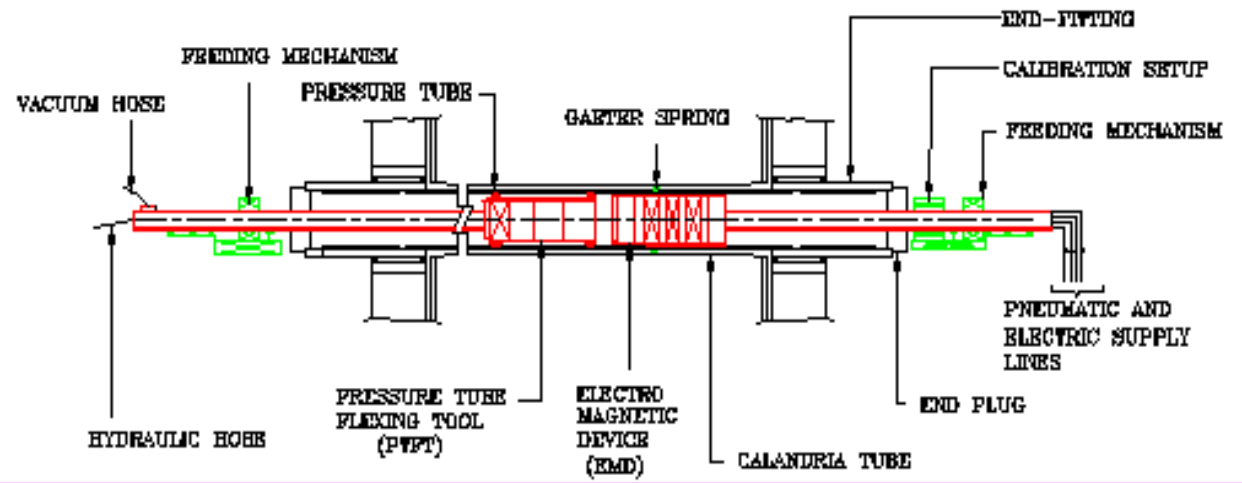
SSST-2



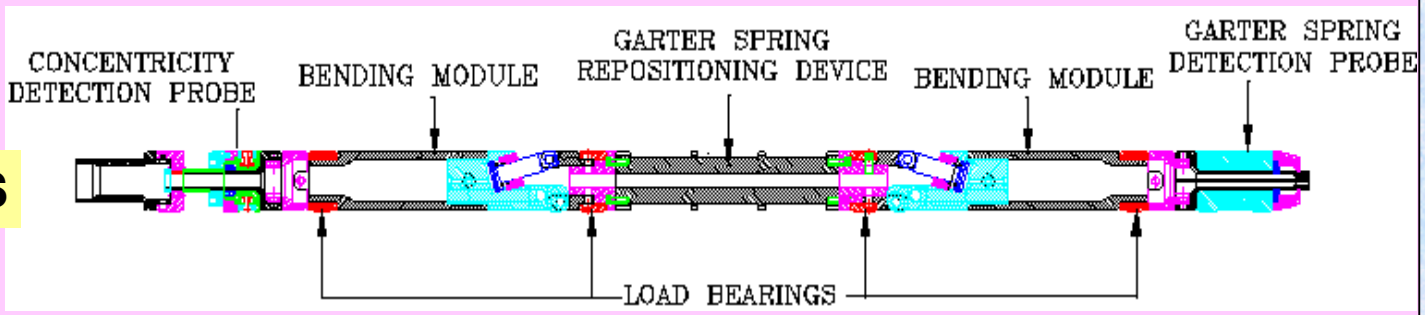
WET SCRAPING TOOL (WEST)

GARTER SPRING REPOSITIONING TOOL: SCHEMATIC VIEW

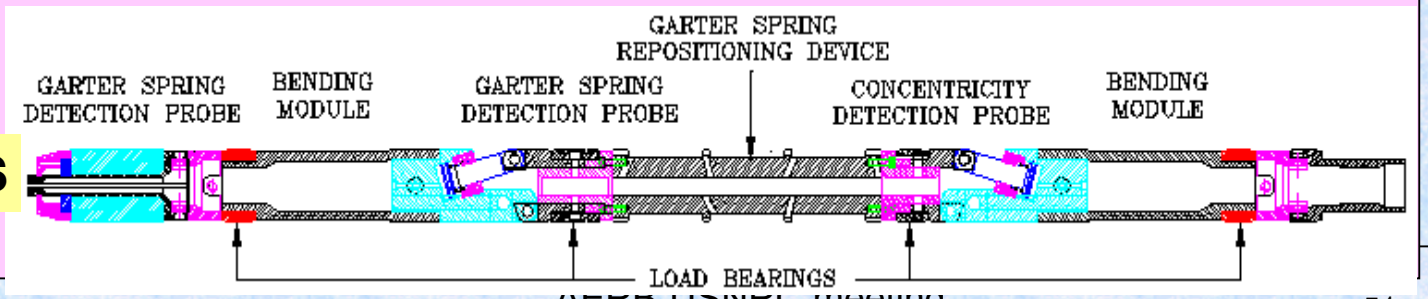
INGRES-1S



INGRES-2S



INGRES-3S



DESIGN MEASURES FOR LIFE MANAGEMENT OF PRESSURE TUBE

- Change of material (Zircoloy-2 to Zr-2.5%Nb)
- Tight fit garter springs (4 Nos.)
- Zero clearance type rolled joints.

In-service inspection requirements for Pressure Tubes:

- **The ISI results of pressure tubes are being reviewed before plant start-up from shut down state for residual life assessment based on SCAPCA & HYCON code .**
- **If situation warrant so, then the sample size of pressure tubes from specific zone for ISI will be increased in the same ISI campaign to bound the degradation.**

In-service inspection requirements for PHT feeder pipes.

- **The selection of outlet feeders for ISI is based on:**

1 **High velocity criteria.**

2 **High stress intensity criteria.**

3 **High survey factor criteria.**

4 **Thinning experience of other plants.**

5 **High seismic load contribution.**

- **Inlet feeders on sample basis (classified on high velocity, high stress intensity& high survey factor criteria) .**

Extent & Interval of ISI on feeders:

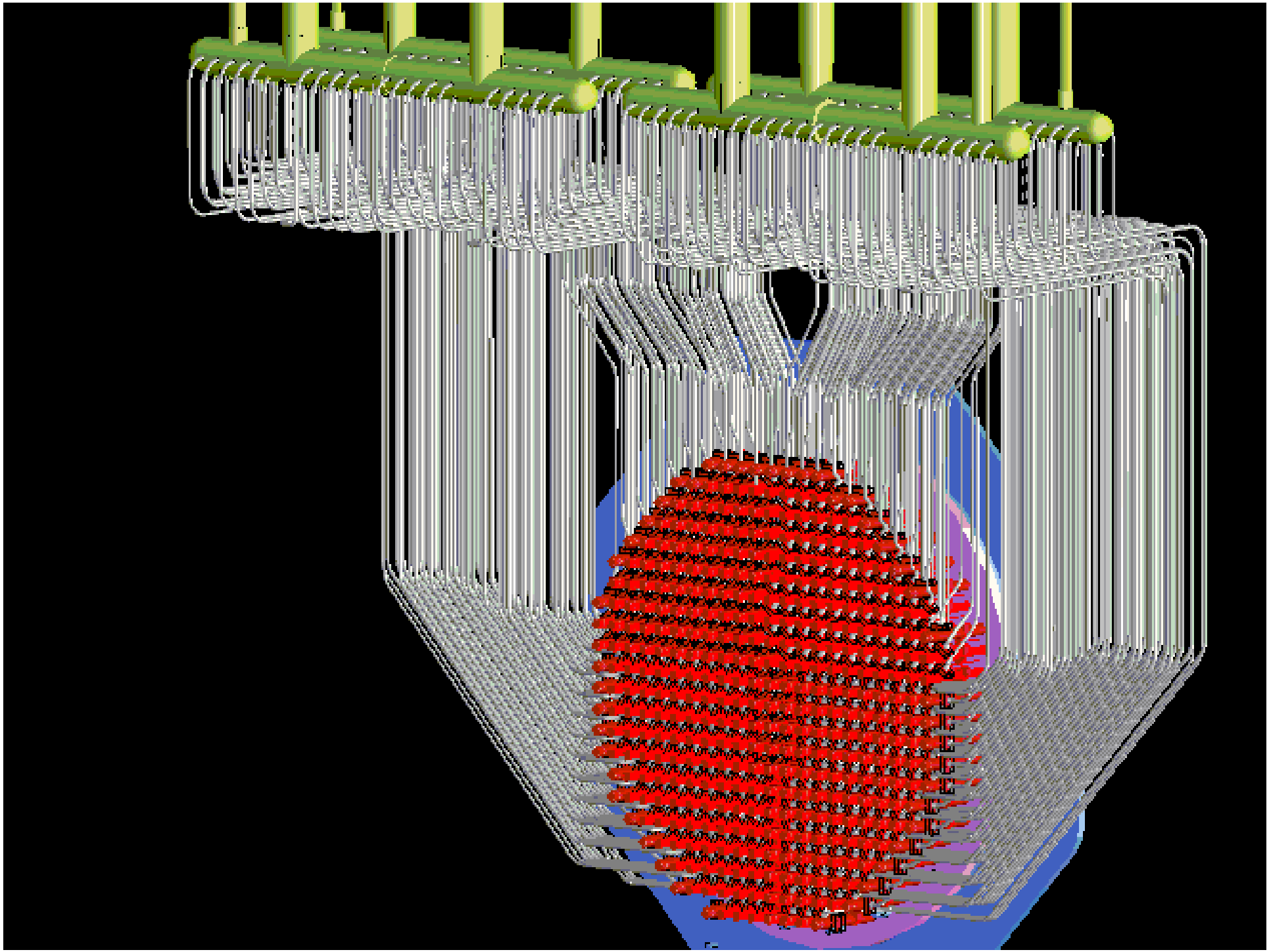
- **Thickness measurement of feeder elbows by UT thickness gauging.**
- **Visual, surface & volumetric examinations of dissimilar metal weld joints .**
- **Visual examination of readily accessible feeders and their supports.**
- **Interval of inspection: 1st ISI interval is 05 Years & subsequent ISI interval is 10 Years.**

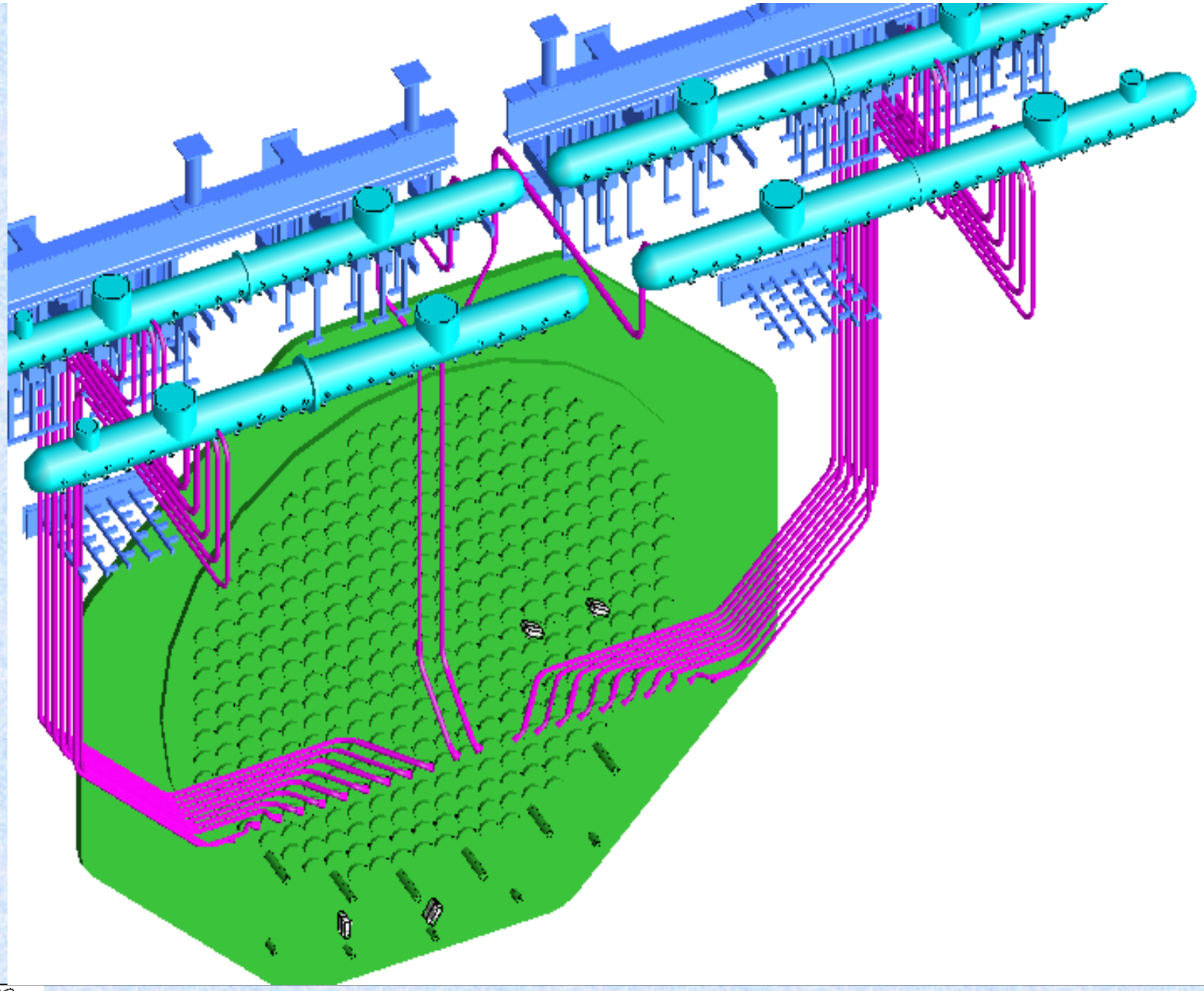
ISI Experience : PHT system Feeders

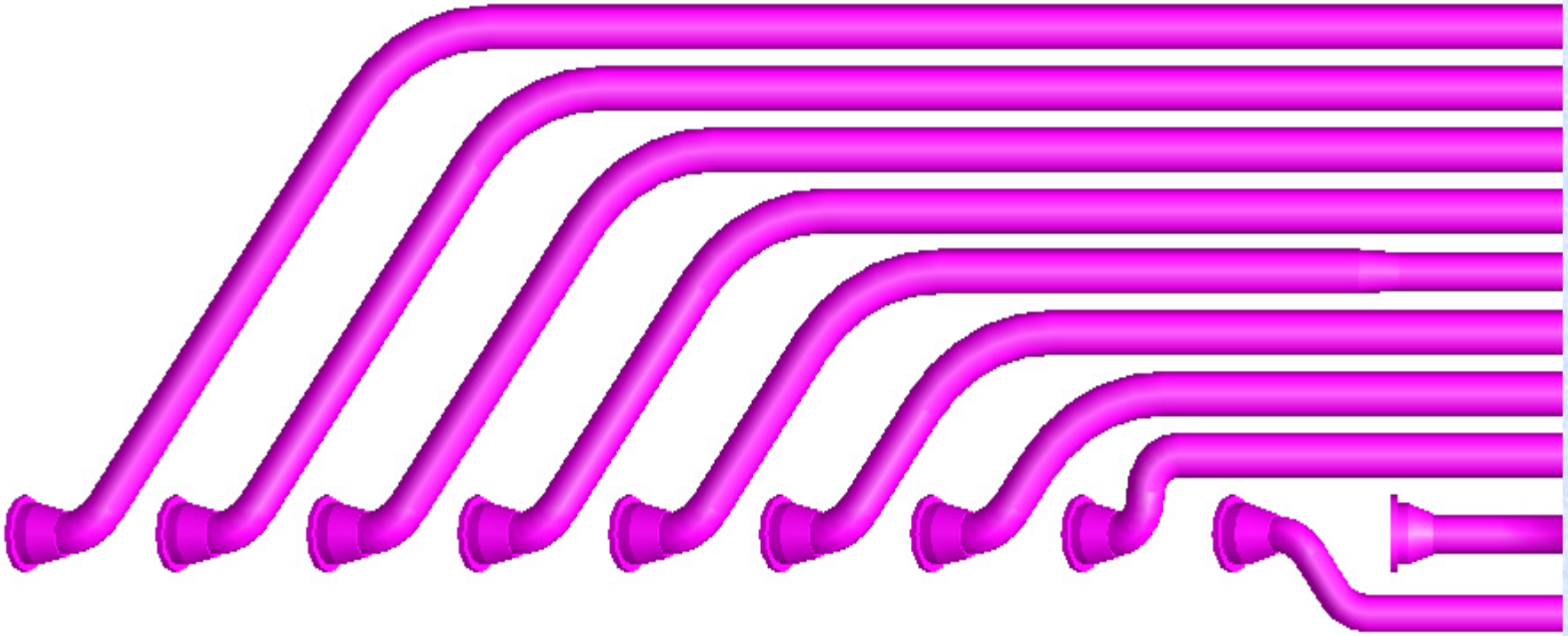
- **Feeders pipes are a components of CANDU PHWR that directly connected to pressure tube in turn reactor core.**
- **PHWR core is constructed with several hundred horizontal pressure tubes, High pressure D2O flows through these tubes coming from and returning to SGs (where the steam is produced to roll the turbine to make electricity) driven by large Primary circulating pumps.**
- **Feeder pipes that are connected to the ends of pressure tubes . Inlet feeder pipes take cool water from the inlet header in to the pressure tubes , and outlet feeder pipes take hot water from the pressure tubes to the outlet header.**

ISI Experience : PHT system Feeders

- **Feeders pipes have complex three dimensional shape , are connected to highly radioactive region of the reactor , are small in diameter .**
- **All these features make feeder pipes highly inaccessible and inspection difficult , time consuming .**
- **PHWR feeders pipe have been degrading in two basic ways, one is Erosion/corrosion/FAC and other is SCC?**
- **In order to monitor these degradation UT thickness check of feeder 1st and 2nd elbow is being done in each ISI campaign manually.**







ISI Experience : PHT system Feeders

- **Erosion/corrosion/FAC results in gradual thinning of feeder pipe wall over a time.**
- **SCC? In feeders is much less predictable and potentially very serious.**
- **Feeder elbows thinning in Indian PHWR has been observed in few feeder elbows.**
- **Developmental activities related to replacement of feeder elbows is currently undertaken.**

MECHANISM OF FEEDER (ELBOWS) THINNING

FOUR POSSIBLE MECHANISMS COULD BE CONTRIBUTING TO THE NON-UNIFORM WALL THINNING OF WHICH ONLY ONE MECHANISM SEEMED APPROPRIATE :

- FLOW ACCELERATED CORROSION (FAC).
- HIGH FLUID SHEAR STRESS.
- CAVITATION, AND
- IMPRINGEMENT OF OXIDE PARTICLES (CRUD).

THE RATE OF FLOW ACCELERATED CORROSION IS INFLUENCED BY A COMPLEX INTERACTION BETWEEN A NUMBER OF VARIABLES INCLUDING MATERIAL COMPOSITION, TEMPERATURE STEAM QUALITY, pH, OXYGEN CONTENT, FLUID VELOCITY, AND GEOMETRY.

ISI Experience : PHT system Feeders

- **The ISI results of feeders are being reviewed before plant start-up from shut down state for residual life assessment.**
- **If situation warrant so, then the sample size of feeders from specific zone for ISI will be increased in the same ISI campaign to bound the degradation.**

ISI Experience : PHT system Feeders

- **Approx. 25 % of total installed feeders were subjected for ISI over period of time, nine feeder elbows of 05 feeders of RAPS-2, where weld build -up has been done to get NWT. Only 13 feeders up to NAPS have shown residual life < 5.5 Yrs. as on July 2004.**
- **Feeder pipes and elbow material from KAPS onwards has been changed and also higher schedule elbow has been used.**
- **From KAPS onwards feeder thinning has not been observed.**
- **For ongoing project (Kaiga-3 & 4, RAPP-5 & 6,TAPP-3 & 4) material up to 0.2% Chromium has been used.**

FEEDER ELBOW THINNING DATA IN INDIAN PHWRs CONTD…..

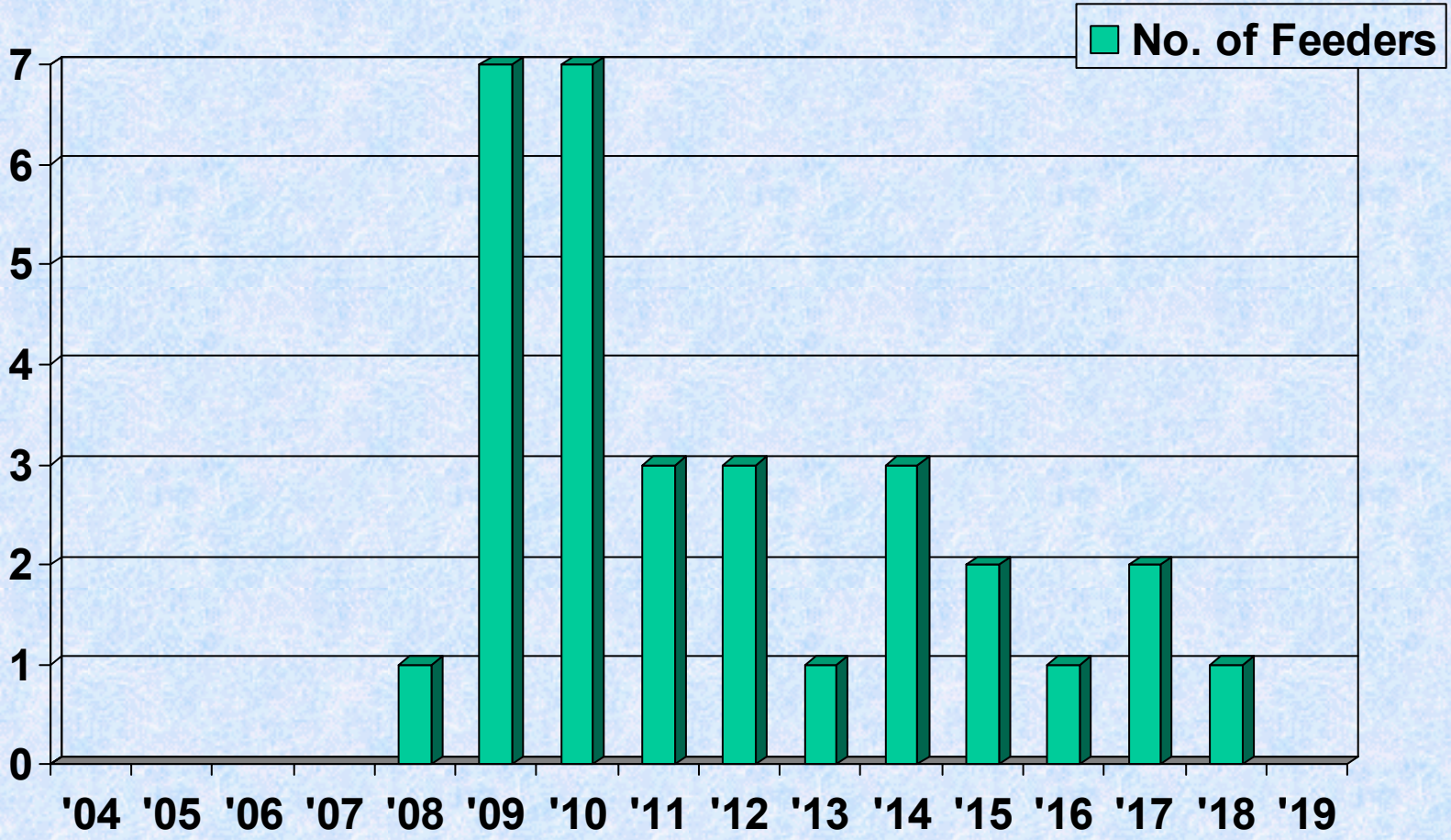
NEW PROJECTS:

- **However With Boiling in 700 MW(e) PHWRs Following Material are Under Consideration for Feeder Pipes and Elbows :**

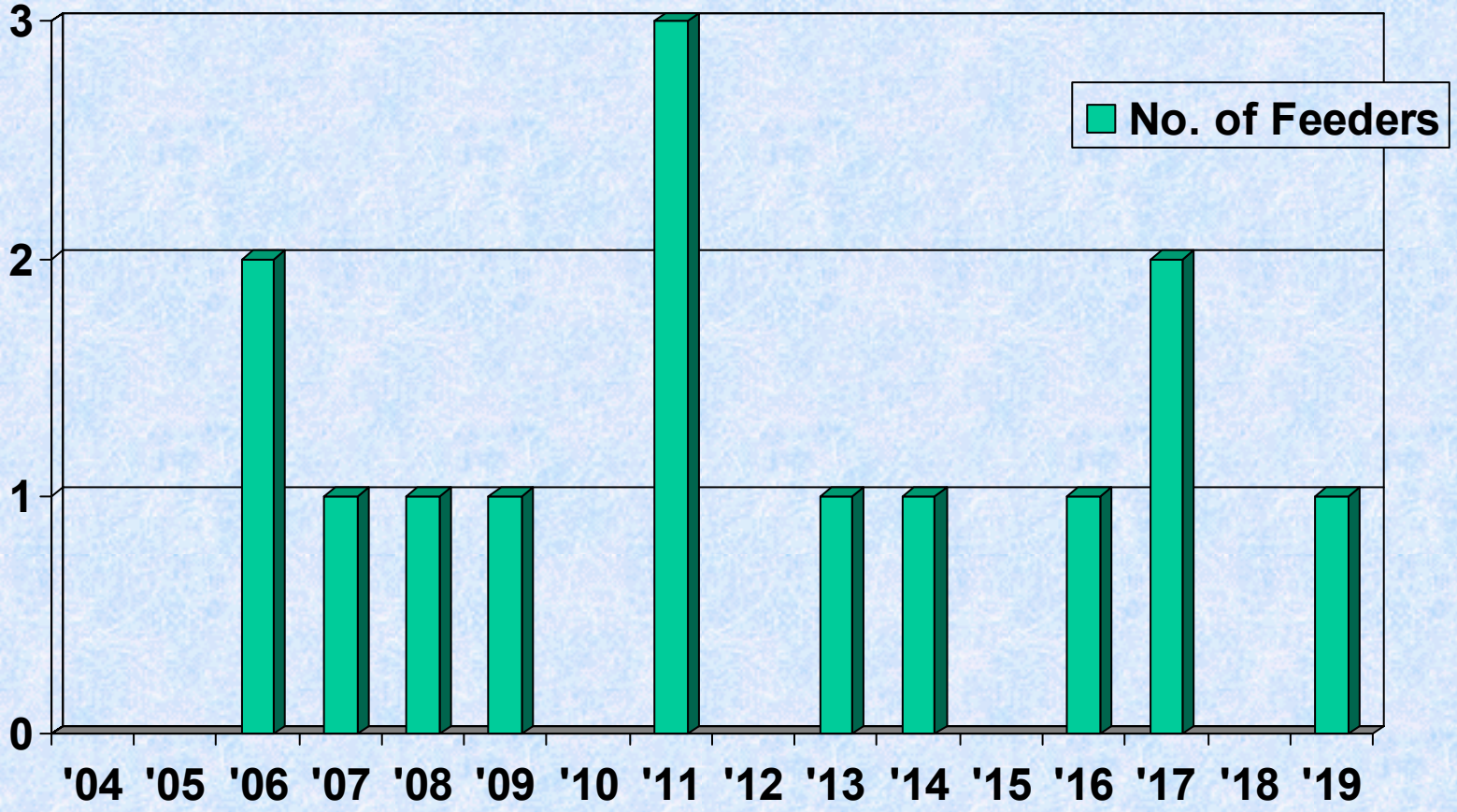
  I) SS-304L (for Elbows and Lower Part of Feeders).

  Ii)Incoloy-600 for Elbows.

RAPS-2 – FEEDER / ELBOW REPLACEMENT PLAN FOR LIFE < 15 YEARS AS IN JULY, 2004



NAPS-1 – FEEDER / ELBOW REPLACEMENT PLAN FOR LIFE < 15 YEARS AS IN JULY, 2004



Typical proactive Feeder management strategy in Indian PHWR for life extensions.

- **Enhanced ISI .**
- **pH control in narrow range.**
- **Weld build-up to get NWT.**
- **Change of feeder(s).**

R&D ACTIVITIES PROPOSED:

- **PERFORMANCE EVALUATION OF CARBON STEEL (CS) FEEDERS/ ELBOWS CONTAINING 0.2% CHROMIUM.**
- **PERFORMANCE EVALUATION OF STAINLESS STEEL (SS) FEEDER/ ELBOWS.**
- **PERFORMANCE EVALUATION OF INCONEL FEEDER ELBOWS.**
- **ON-LINE / AUTOMATIC MONITORING OF THICKNESS MEASUREMENT OF FEEDER PIPES / ELBOWS BY ULTRASONIC METHOD.**

In-service Inspection requirements of Steam Generators (SGs):

- **As a minimum of 20 % of total number of tubes of each SG are subjected for Eddy-current testing in one ISI interval.**
- **Selection of tubes from specific & random sample.**
- **Visual , surface & volumetric examinations of channel & shell side weld joints .**
- **SG support & fasteners examination.**
- **Removal of section of one tube in a deposit region for metallurgical examinations.**
- **Interval of inspection : 1st ISI-05 Yrs, subsequent ISI -10 Yrs.**

DESIGN MEASURES FOR LIFE MANAGEMENT OF STEAM GENERATOR

- **Later generation SGs are amenable for ISI.**
- **Hairpin type SGs Design change to mushroom type SGs.**
- **Change of tube material (Monel to incoloy-800)**

ISI Experience : Eddy current testing of Steam Generators.

- **IN PHWR , the SGs & D_2O to H_2O HXs need periodic inspection of tubes by Eddy current testing.**
- **Steam Generators are large Heat Exchangers using the heat from Primary reactor coolant to generate steam in the secondary side to drive Turbo Generators.**
- **Thin walled tubes of SGs are important part of reactor coolant pressure boundary and in fact comprise a considerable area of total primary system pressure retaining boundary.**
- **The major safety function of SGs is to act barrier between radioactive primary side and non-radioactive secondary side.**

ISI Experience : Eddy current testing of Steam Generators.

- **Any degradation which impairs this function and eventually may lead to tube rupture need to be arrested/addressed at an early stage.**
- **The common deterioration in SGs tubing is thinning of tubes due to corrosion/erosion, denting, wear,fretting and pitting.**
- **Eddy current testing (ET) of SG tubes is being extensively carried out as a part of ISI.**
- **During initial period (late 1970s) , the ET was carried out with single /dual frequency equipment.**

ISI Experience : Eddy current testing of Steam Generators.

- **There have been considerable improvements in ET techniques. Multifrequency ET system has been used since early 1990s. Which can enable us detect the defect under the baffle plate**
- **Lately use has been made of robotic systems for remote semi-automatic eddy current testing equipment with probe pusher puller.**
- **This remotely controlled fully automatic device are capable of traversing the probe head parallel to the tubesheet to the next selected tube, pushing the eddy current probe into the full length of the tube and recording information as the probe is subsequently retracted.**

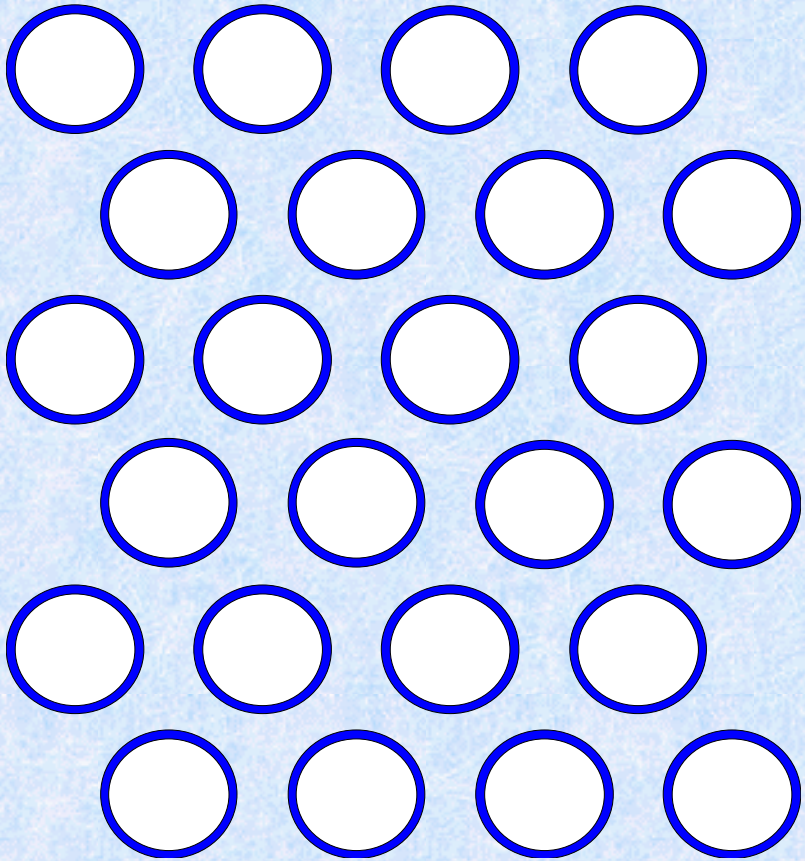
ISI Experience : Eddy current testing of Steam Generators & Heat Exchangers.

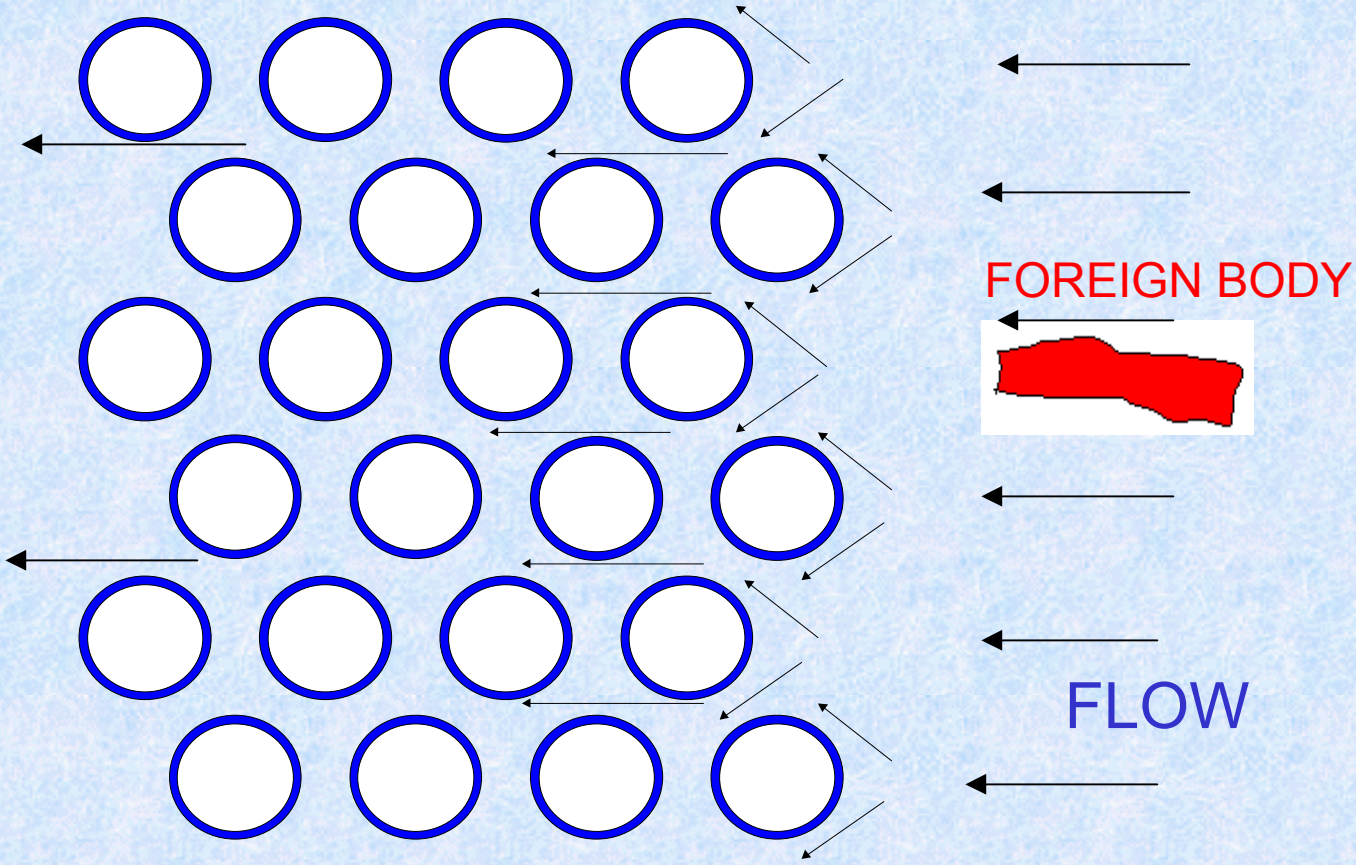
- **This would reduce the time of inspection as well as man-rem consumption.**
- **No generic degradation in SG tubes has been observed so far in Indian PHWR from NAPS onwards. However few SG tubes (07 Nos.) found leaky due to hitting of foreign material from shell side of the tubes which possibly existed as construction debris .**
- **Degraded section of tubes from three leaky tubes was removed for metallurgical examinations. Studies does not reveal any generic degradation.**
- **D_2O to H_2O HXs from MAPS onwards have not shown any generic degradation. This is because of intermediate loop provided at Process Water System.**

ISI Experience : Eddy current testing of Steam Generators.

- **The ISI results of SGs are being reviewed before plant start-up from shut down state.**
- **If situation warrant so, then the sample size of SG tubes from specific zone for ISI will be increased in the same ISI campaign to bound the degradation.**

STEAM GENERATOR TUBE MATRIX TRIANGULAR PITCH 22 MM

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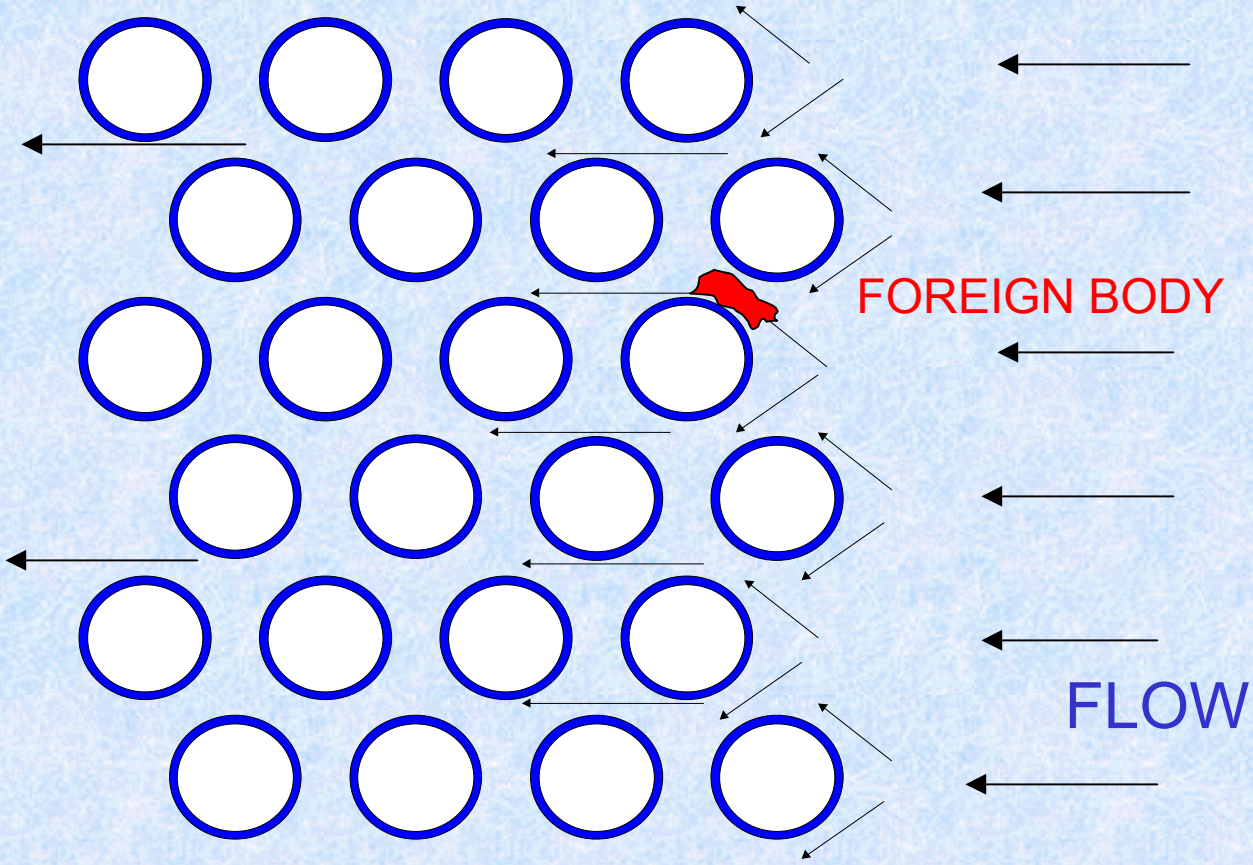
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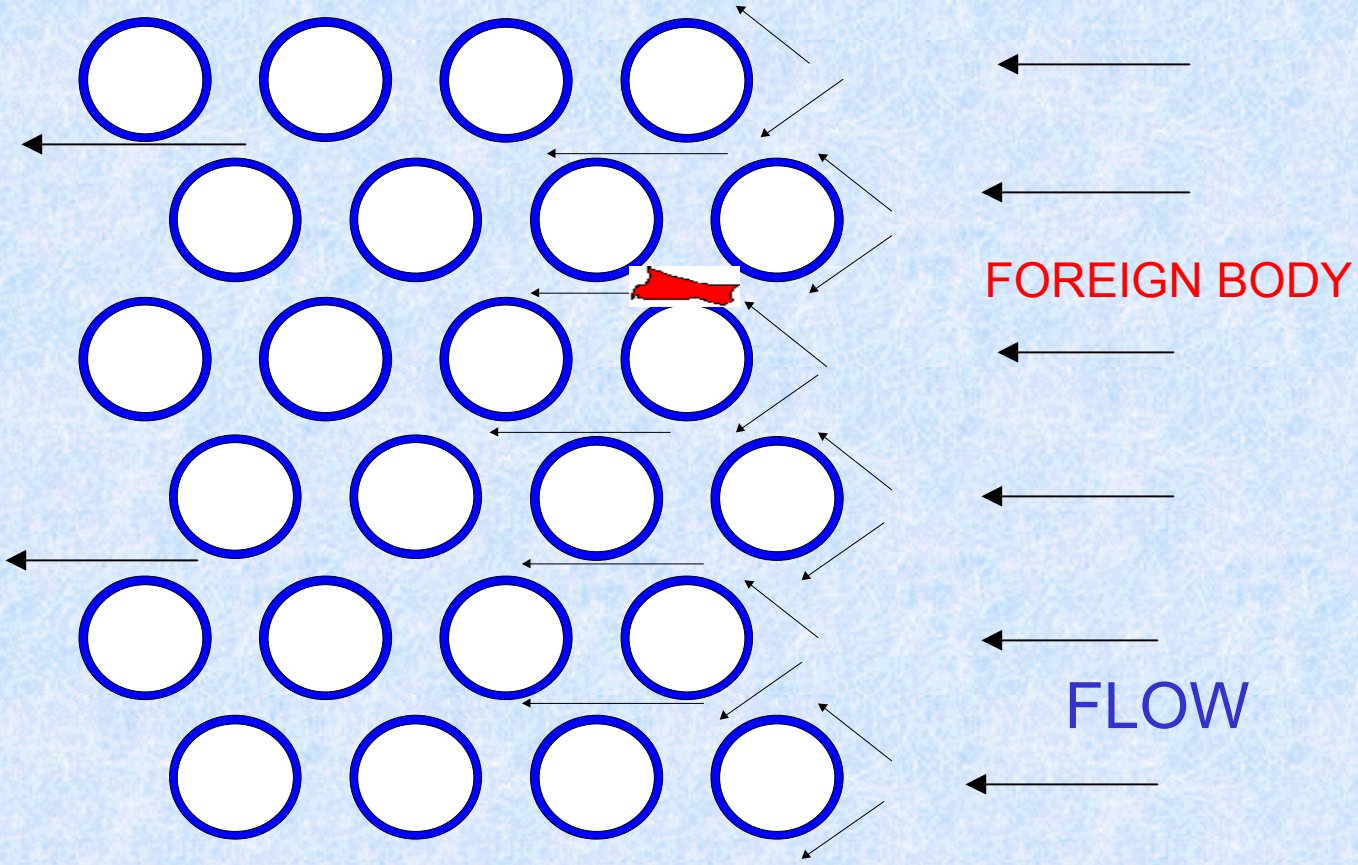
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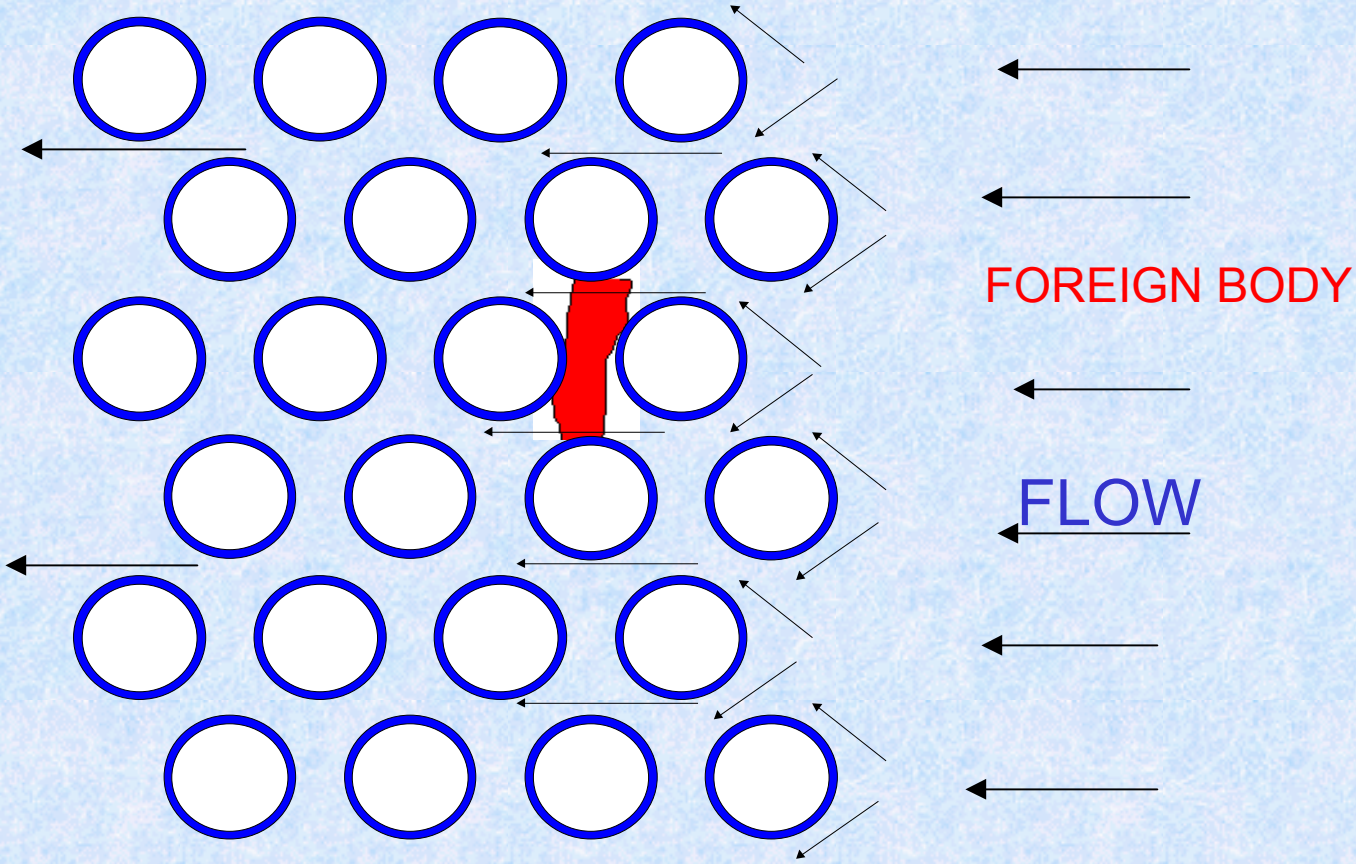
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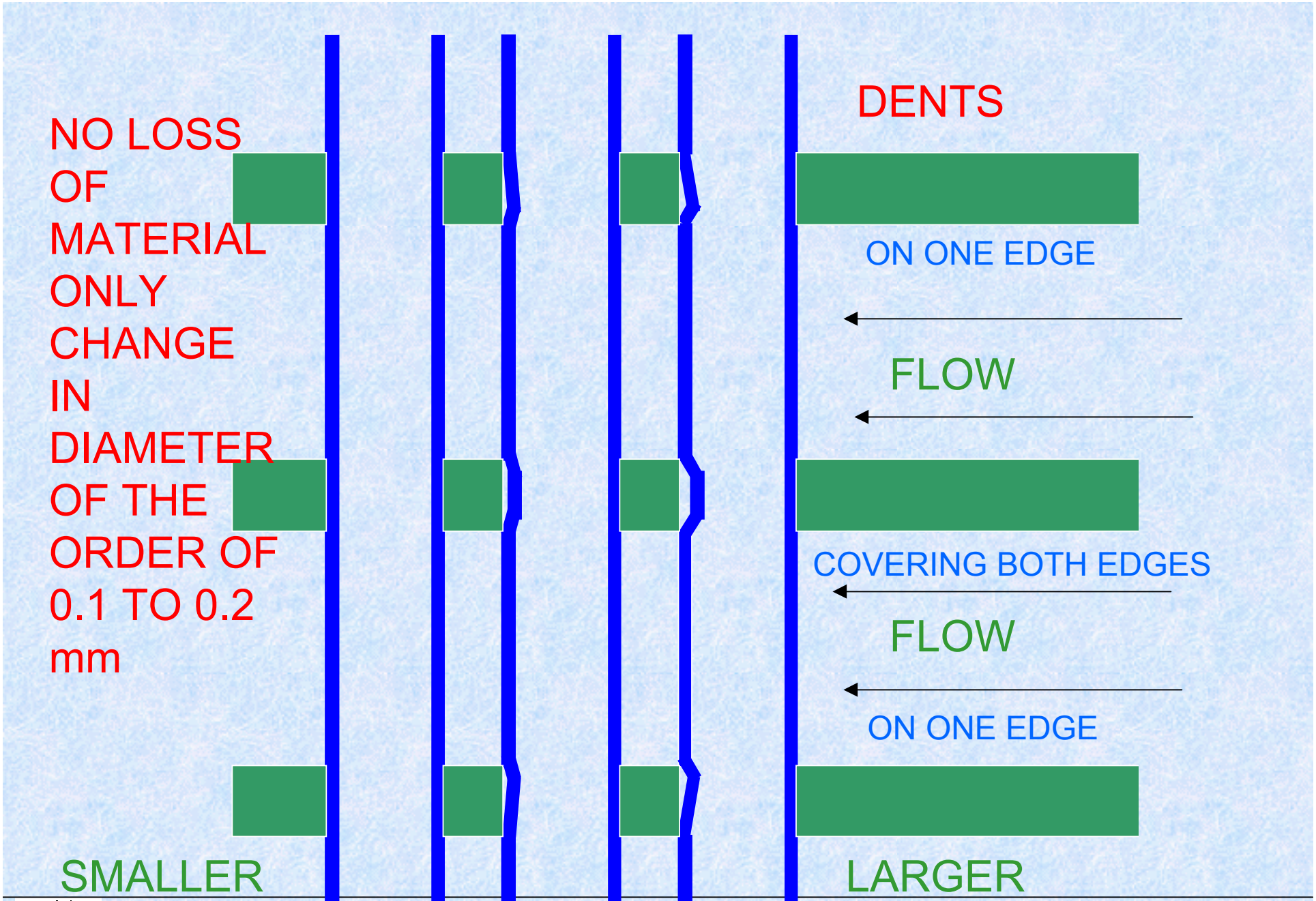
NO LOSS OF MATERIAL ONLY CHANGE IN DIAMETER OF THE ORDER OF 0.1 TO 0.2 mm
DENTS
ON ONE EDGE
FLOW
COVERING BOTH EDGES
FLOW
ON ONE EDGE
SMALLER
LARGER

Typical proactive SG management strategy in Indian PHWR for life extensions.

- **Enhanced Tube bundle Inspection/ Interpretation.**
- **SG surveillance Tubes.(Removal of one SG tube or portion of tube periodically for metallurgical evaluation) .**
- **Secondary side internal inspection.**
- **Secondary side chemistry control.**
- **SG cleaning program.**

In-service inspection requirements of piping weld joints:

- **Visual, surface and volumetric examinations of minimum of 25 % of total weld joints in each pipe run. UT thickness check on elbows on sample basis.**
- **Selection of weld joints for ISI :**

1 **The joints having high fatigue usage factor/ high stress intensity ratio.**

2 **Terminal weld joints.**

3 **Dissimilar weld joints.**

4 **Intersection weld joints.**

In-service inspection requirements of pumps/valves.

- **Examinations are limited to at least one pump & one valve within each group of pumps/valves performing similar function in the system.**
- **Extent of examination for pump/valves includes: visual, surface & volumetric examinations of casing weld joints (if any) , Visual examination of internal fluid boundary of pump/valve casing and visual & surface examinations of pump/valve fasteners. Volumetric examination of PCP flywheel.**
- **Interval of inspection: 1st ISI interval is 05 Years & subsequent ISI interval is 10 Years.**

Conclusions:

- **During Periodic Safety Review conducted by Regulatory Body, the Ageing Management program of Indian PHWR NPPs is monitored.**
- **Based on Ageing Management Programme , components like Pressure Tubes & PHT system Feeders have shown deteriorations before their design life is over.**
- **For Pressure Tubes (Zircaloy-2 type) extensive /enhanced ISI and replacement is envisaged.**
- **For PHT system feeders extensive/enhanced ISI programme is envisaged .**

THANK YOU