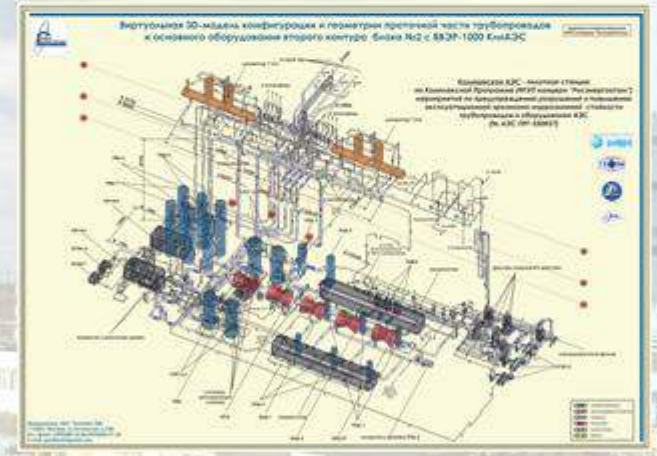
Дирекция материаловедения
ФГУП концерн «Росэнергоатом»

Scientific Grounds and Practical Methods for Prevention of Local Erosion-Corrosion (LEC) of NPP Pipelines and Components

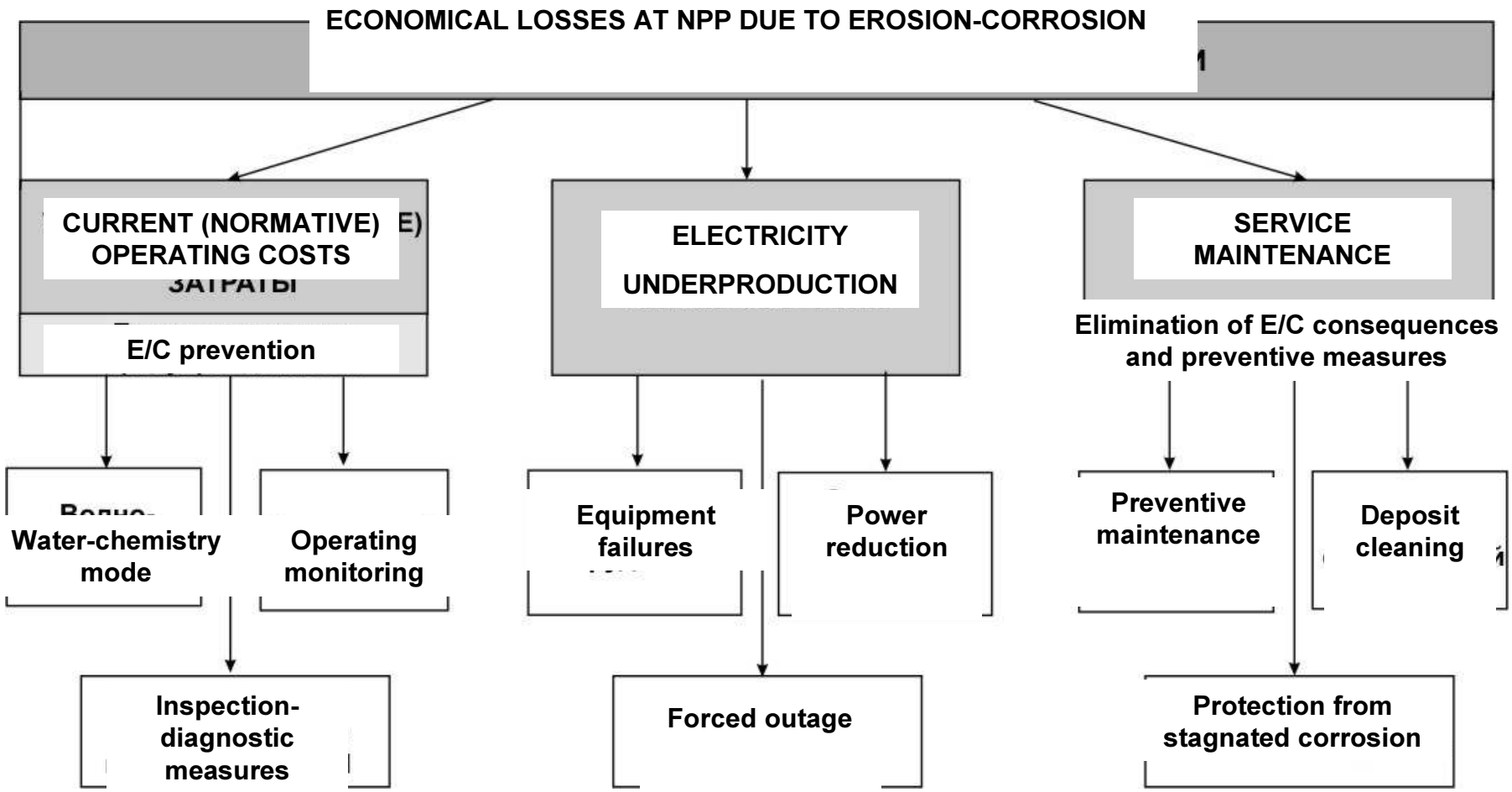


Reporter:

Doctor of Science
Tomarov Grigoriy Valentinovich
«Geoterm-EM» Director General

IAEA Technical Workshop, April 21-23, Moscow

Economic Losses during NPP Operation due to Metal Erosion-Corrosion in the Circuit



Examples of Erosion/Corrosion Damage of NPP Secondary Circuit Pipelines

USA, Surry NPP, 02.12.1986, unit 2, 822 MW

Supply water pipeline bending to PN, 457mm

USA, Arkansas NPP, 04.1989, unit 2, 1095 MW

Heating steam extraction pipeline to HP reheater

USA, Millstone NPP, 11.1991, unit 2, 863 MW

KGP pipeline bending

Finland, Loviza NPP, 05.1990, unit 1, 445 MW

Main Feedwater Pipeline

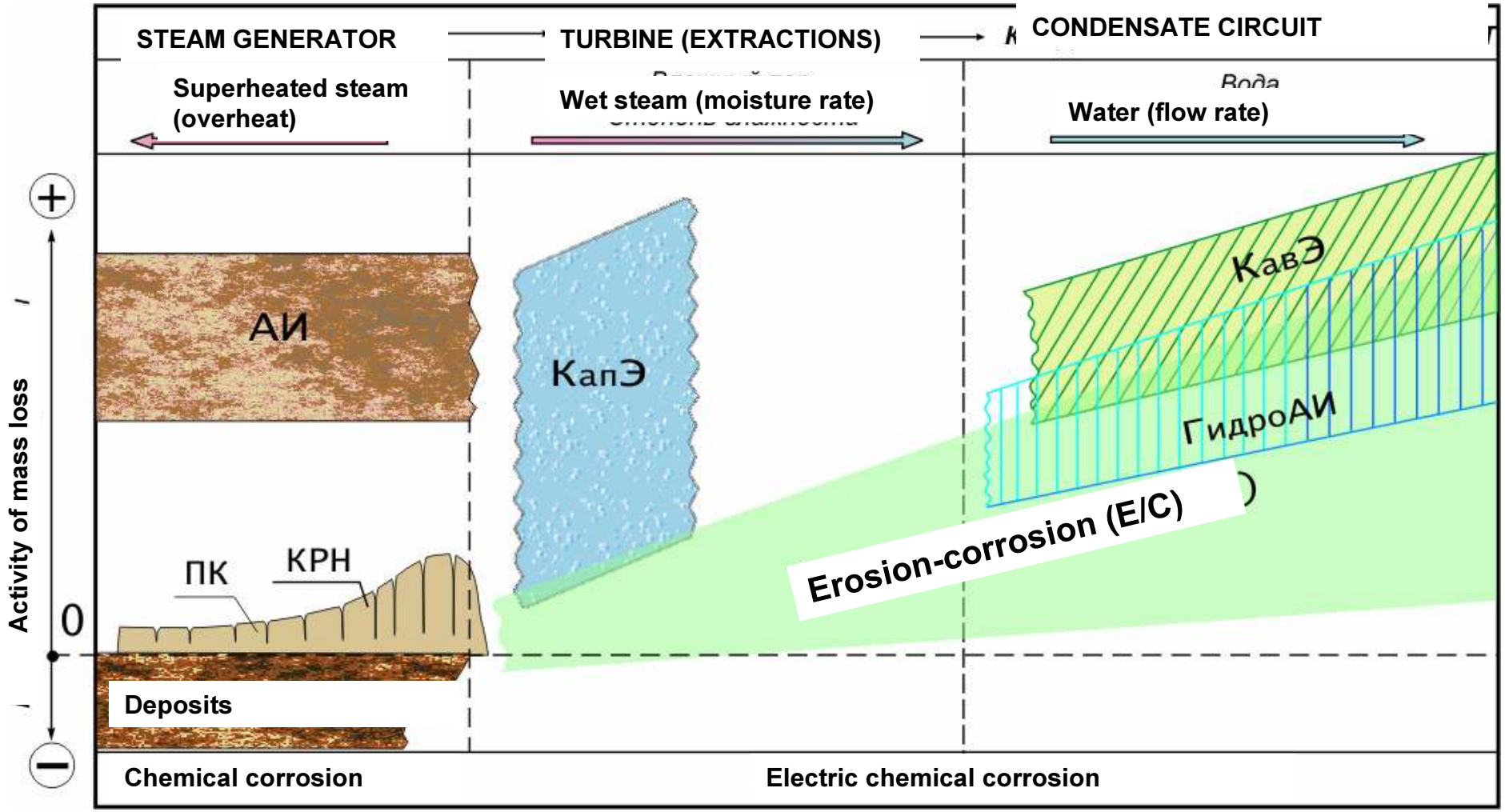
Japan, Mihama NPP, 08.2004, unit 3, 826 MW

Feedwater pipeline, 560mm

Russia, Balakovo NPP, 11.2004, unit 2, 1000 MW

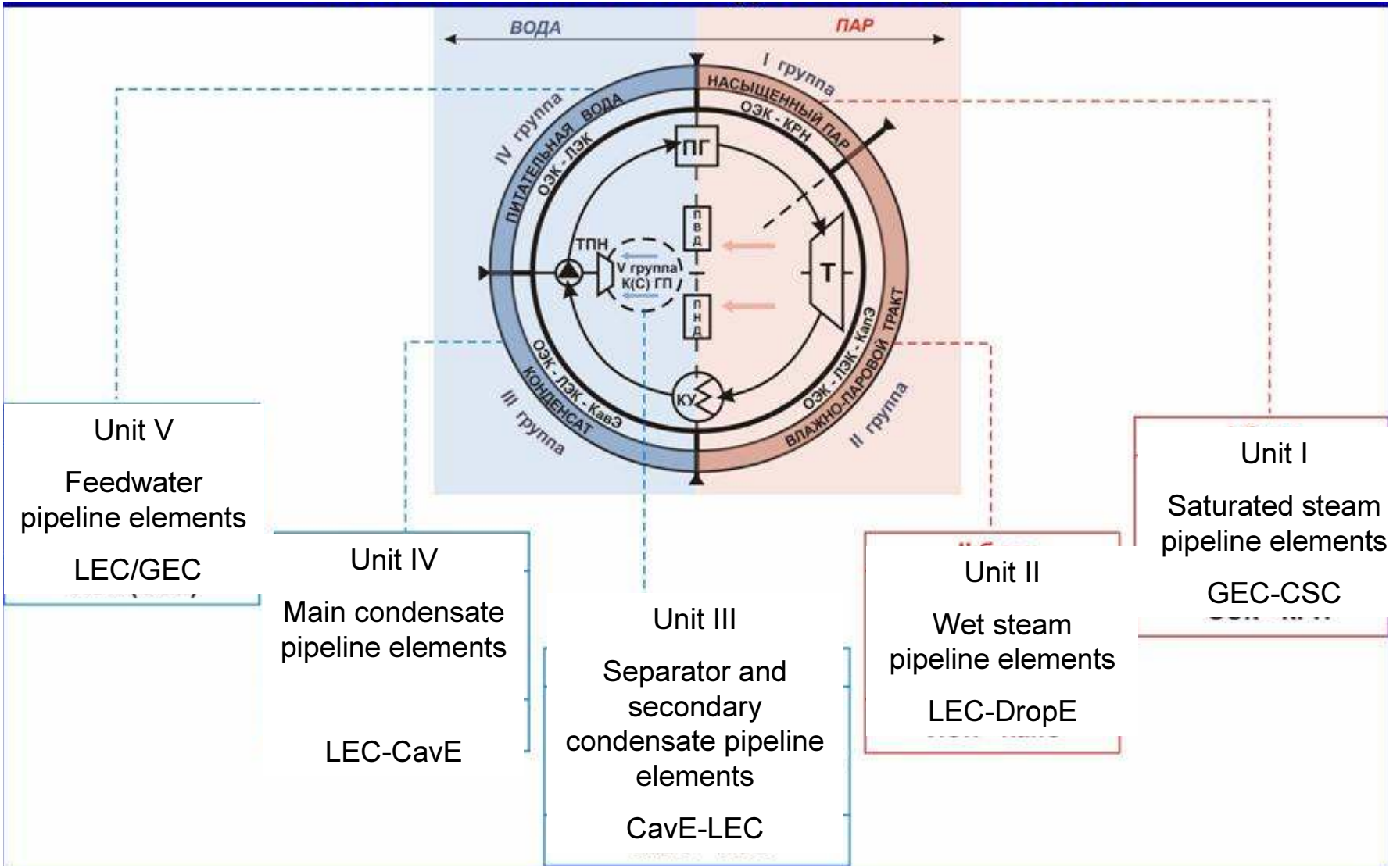
Feedwater regulator bypass pipeline, 106 x 8mm

Conditions and Activity of Main Mechanisms Implementation of NPP Components and Pipelines Metal Damage

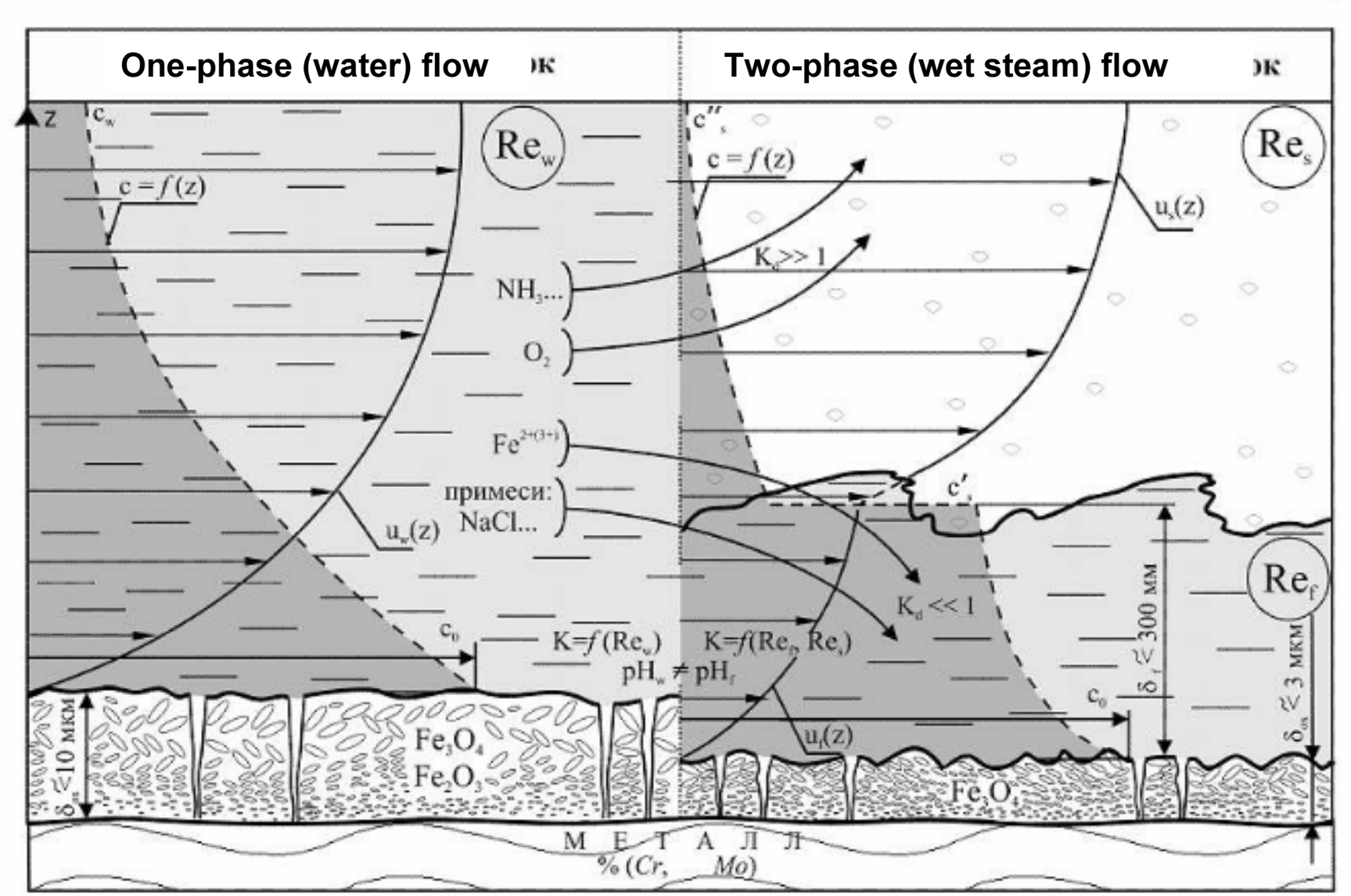


АИ – abrasive wear, КРН – corrosion stress cracking,
ПК – pitting corrosion, КапЭ – droplet impingement erosion,
КавЭ – cavitation erosion, ГидроАИ – hydro-abrasive wear

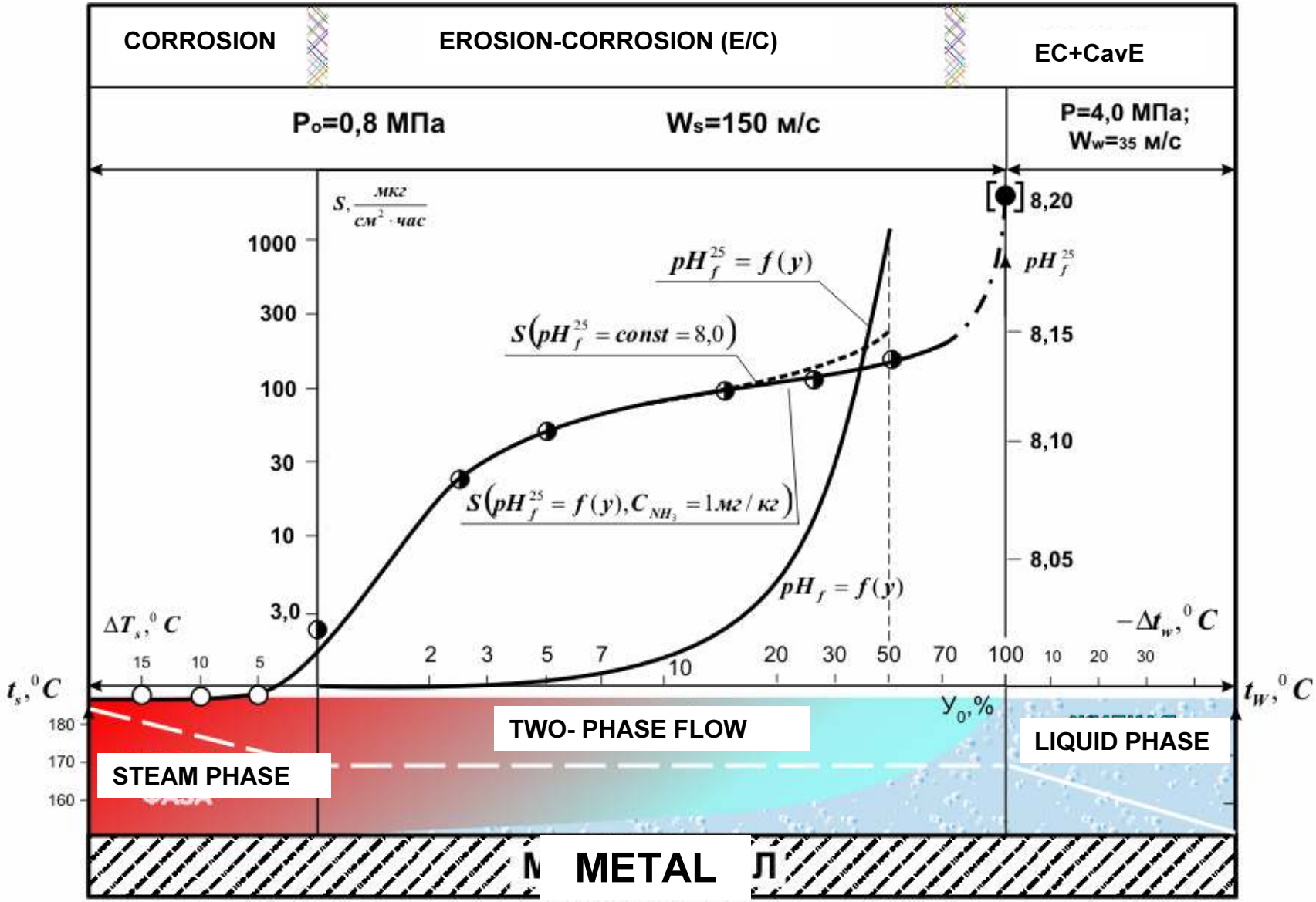
Generation of Information-Analytic Units of Damage Probability Data Array for NPP Secondary Circuit Pipelines by Conditions of Metal Damage Mechanisms (Thinning) Implementation (Dominating)



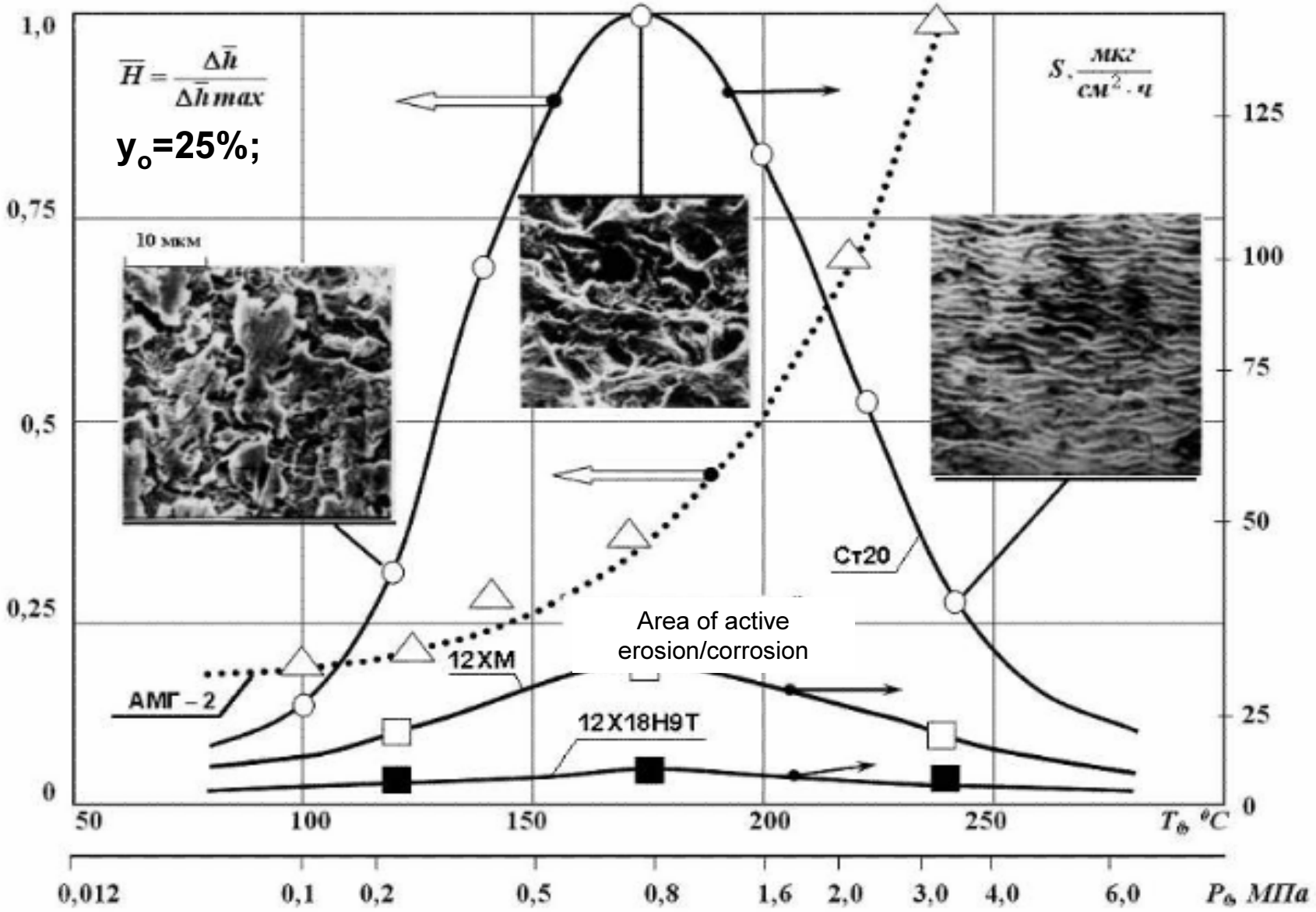
Physical-Chemical Erosion-Corrosion in One- and Two- Phase Flow



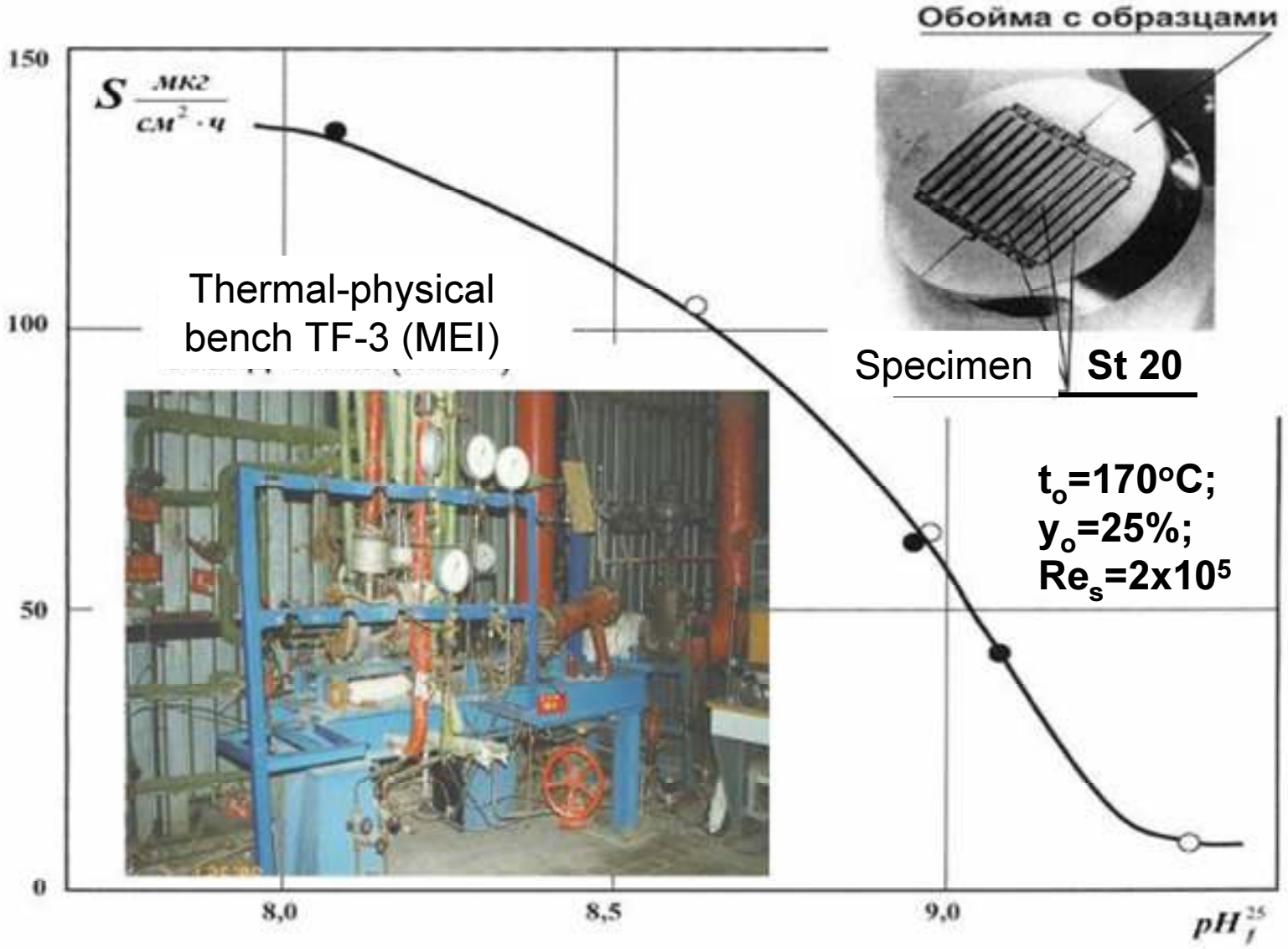
Experimental Investigations of H_2O Phase Influence on Flow and Metal (St 20) Interaction Mechanism and E/C Strength from Moisture Rate (experiments of MEI)



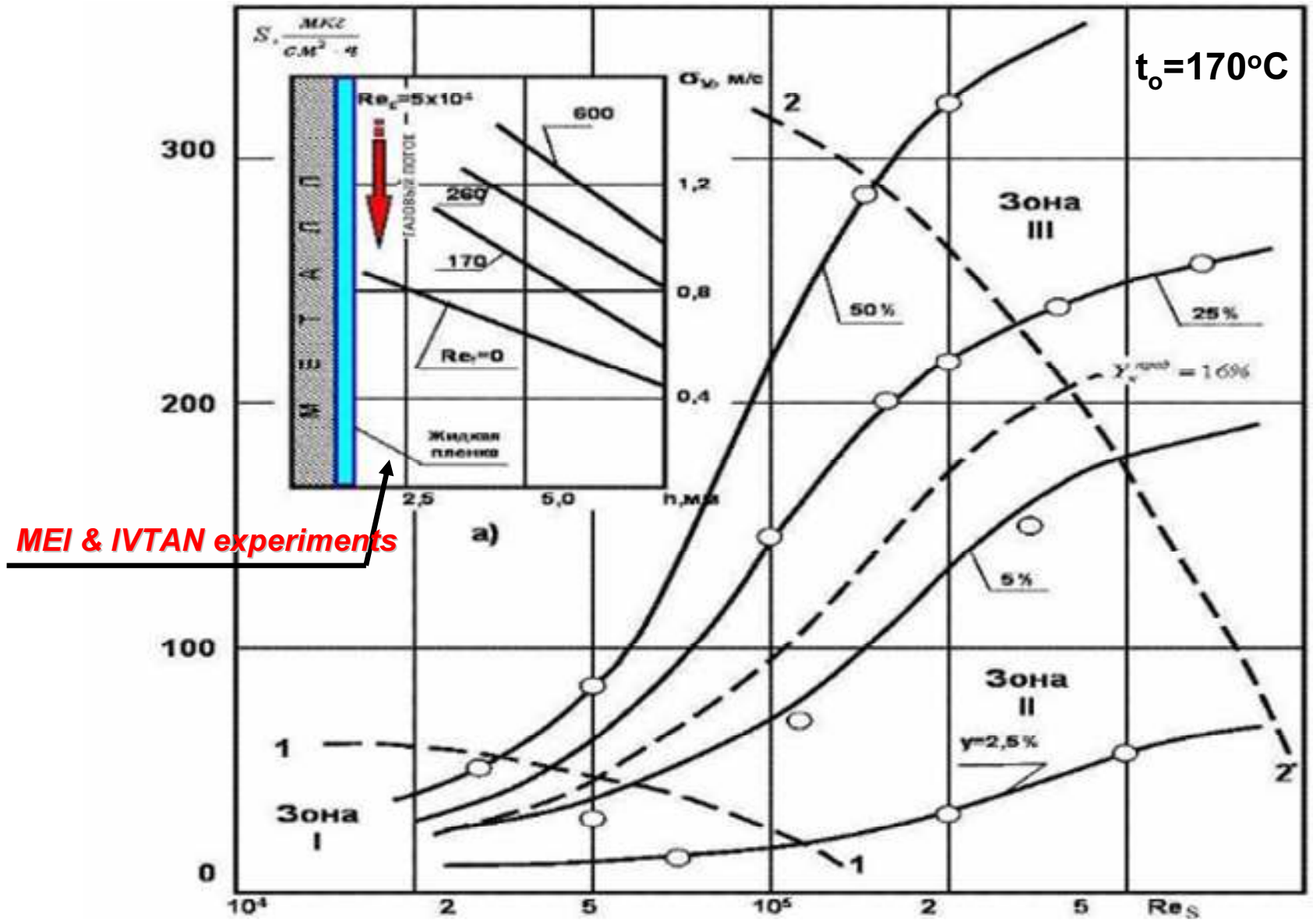
Experimental Investigations of Wet Steam Influence upon Erosion-Corrosion Activity (experiments of MEI)



Results of Experimental Investigations of E/C Dependence on pH_f Value, Liquid Phase (film) in Two-phase Flow (experiments of MEI)



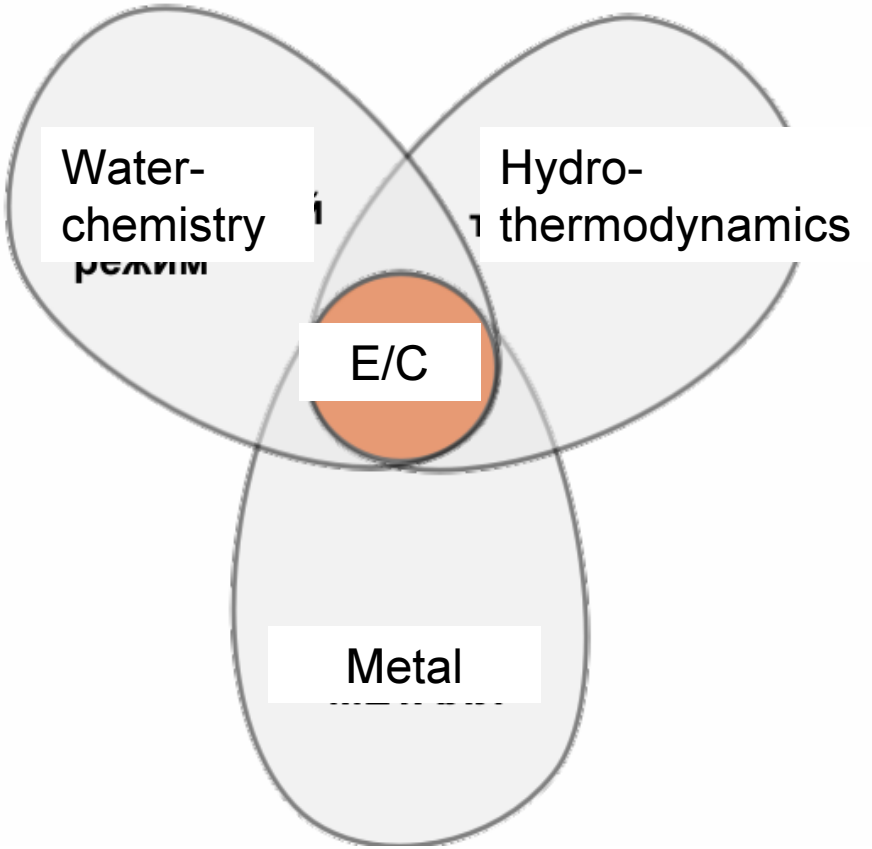
Results of Experimental Investigations of Carbon Steel E/C Activity (St 20) under Different Re_s and y_o values (experiments of MEI)

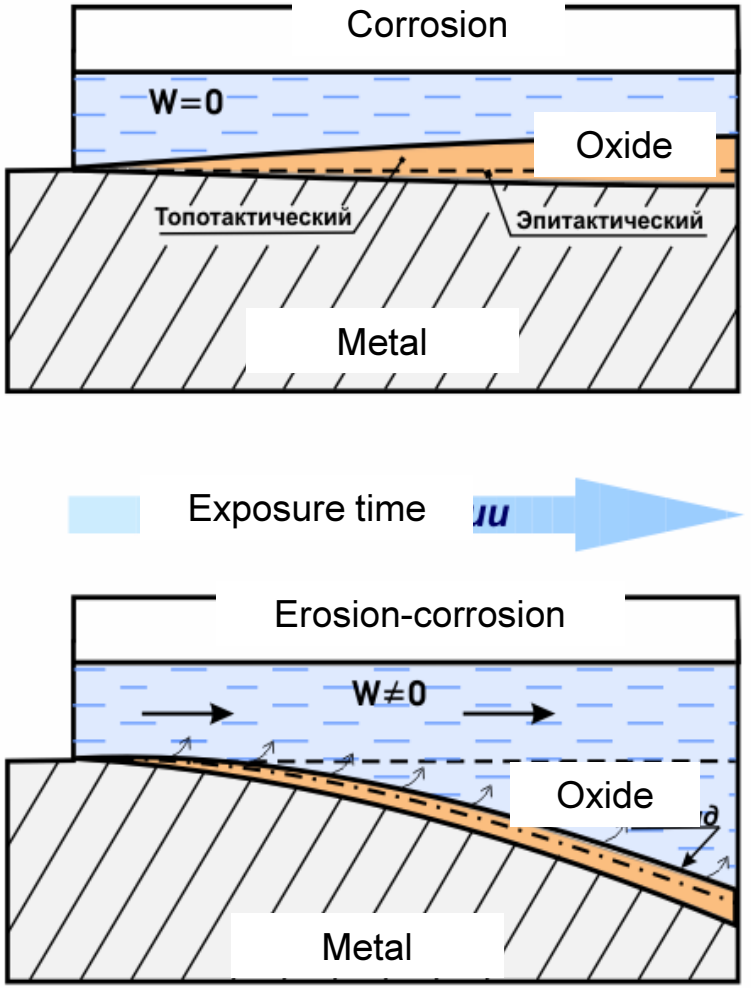


MEI & IVTAN experiments

NPP Metal Erosion-Corrosion

One-(water) and two-phase (wet steam) flows





General Erosion-Corrosion (GEC) of NPP Pipelines and Components Metal

GEC influences on reliability and operational resource

- ***It is characterized by*** **moderate wear activity (up to 0,1 mm/year) and is widely spread.**
- ***it is the reason for:***
  - ***general wall thinning*****;**
  - **environment contamination by Fe.**
- ***GEC consequences:***
  - ***reduction of pipeline elements design resource and*** **premature wear of components;**
  - **generation of deposits in the circuit (SG, turbine etc.)**
- ***economic losses:***
  - **reduction of *thermal-mechanical components performance* efficiency;**
  - **increase of hydraulic losses in pipelines;**
  - **expenses for inspection-diagnostic and preventive maintenance work.**

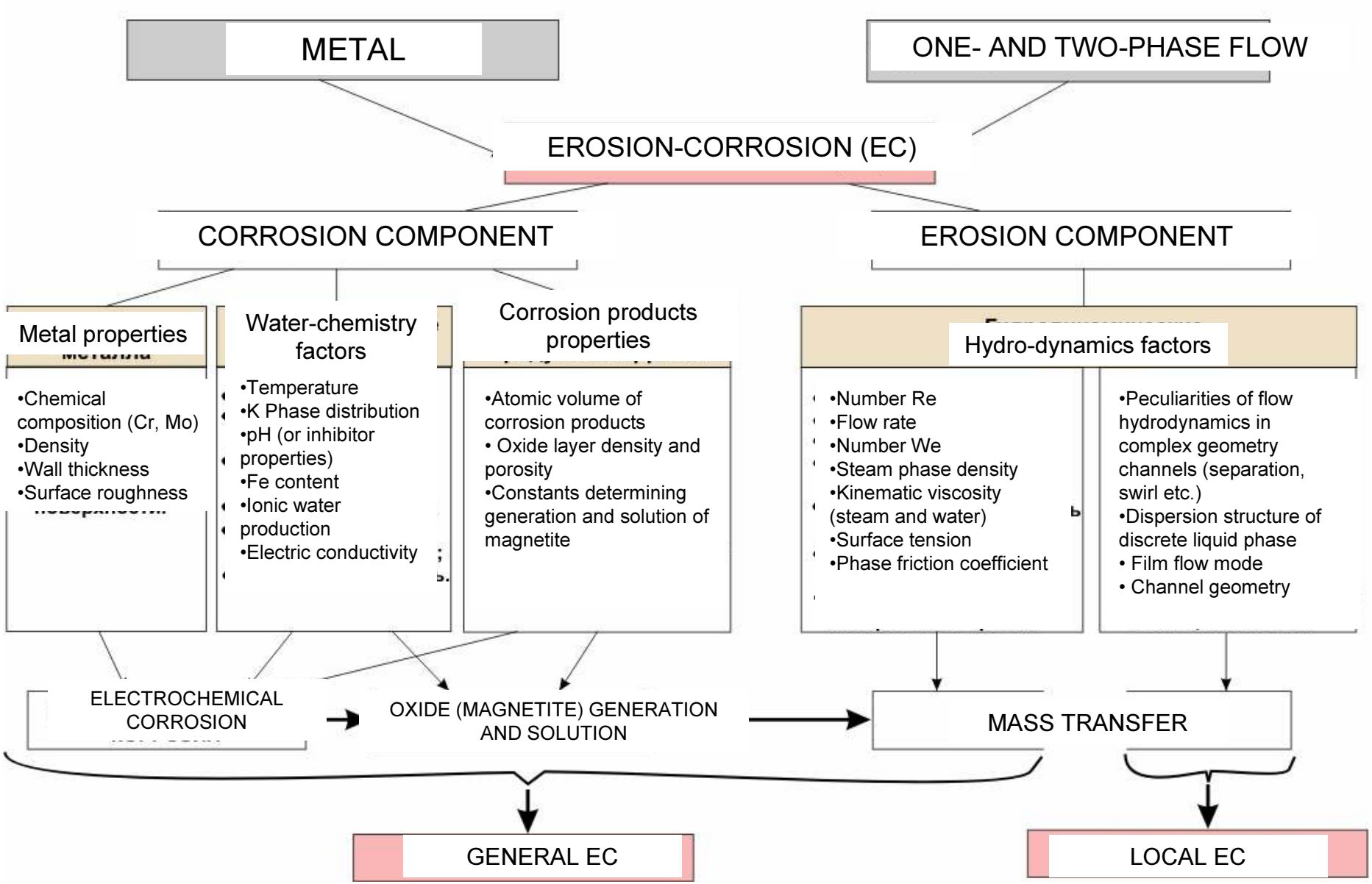
Local Erosion-Corrosion (LEC) of NPP Pipelines and Components Metal

LEC influences on safety, reliability and operational resource

- ***it is localized in the channels with complex geometry;***
- ***it is characterized by high wear activity (≥ 0,5-3,0 mm/year);***
- ***it is the reason for local damage (thinning);***
- ***LEC consequences:***
  - **generation of holes;**
  - **pipelines and components damage;**
  - **accidents (incl. victims);**
- ***economic losses:***
  - ***expenses to eliminate consequences of EC damage and accidents*;**
  - **damage from forced components switching off and unit outage as a whole (capacity factor reduction);**
  - **expenses for inspection-diagnostic measures and preventive maintenance work.**

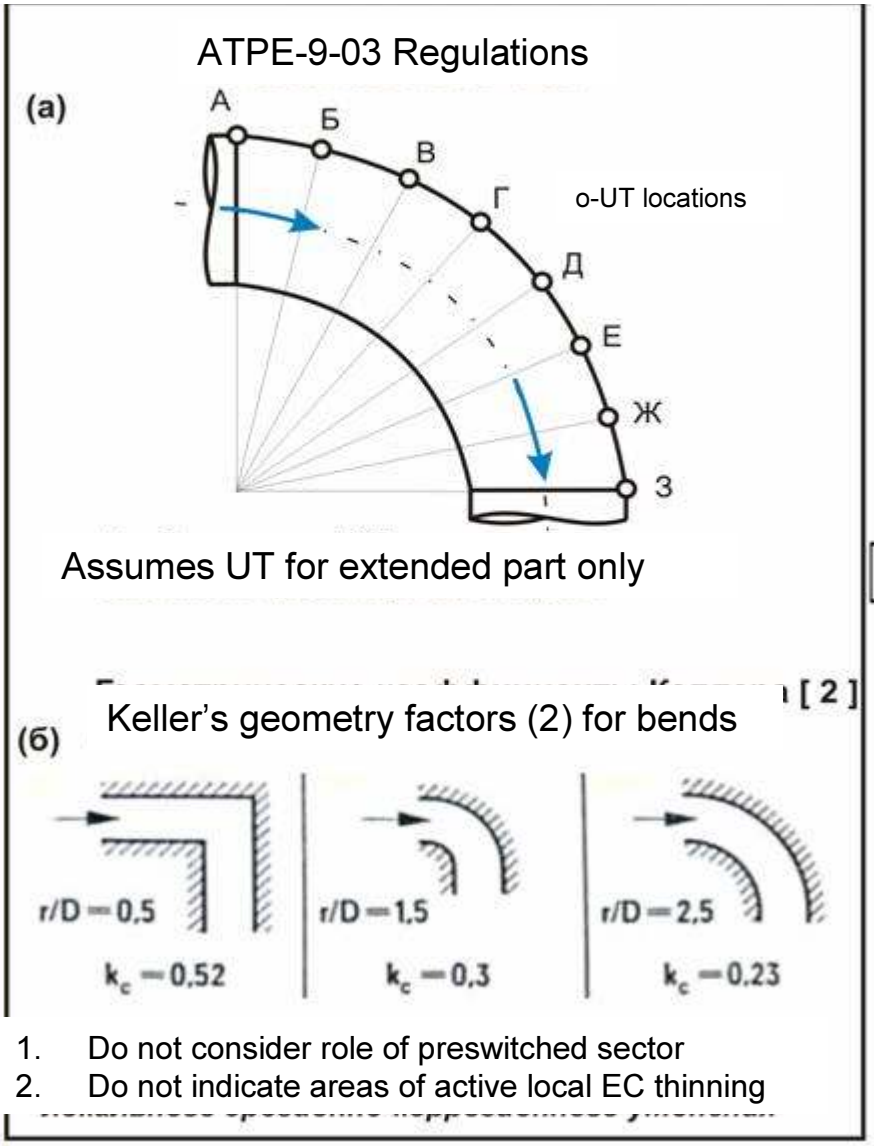
Losses from daily outage of 1000 MW unit – more than 15 mln. rubles

Main Factors and Processes of Erosion and Corrosion Components of NPP Secondary Circuit Metal Erosion-Corrosion



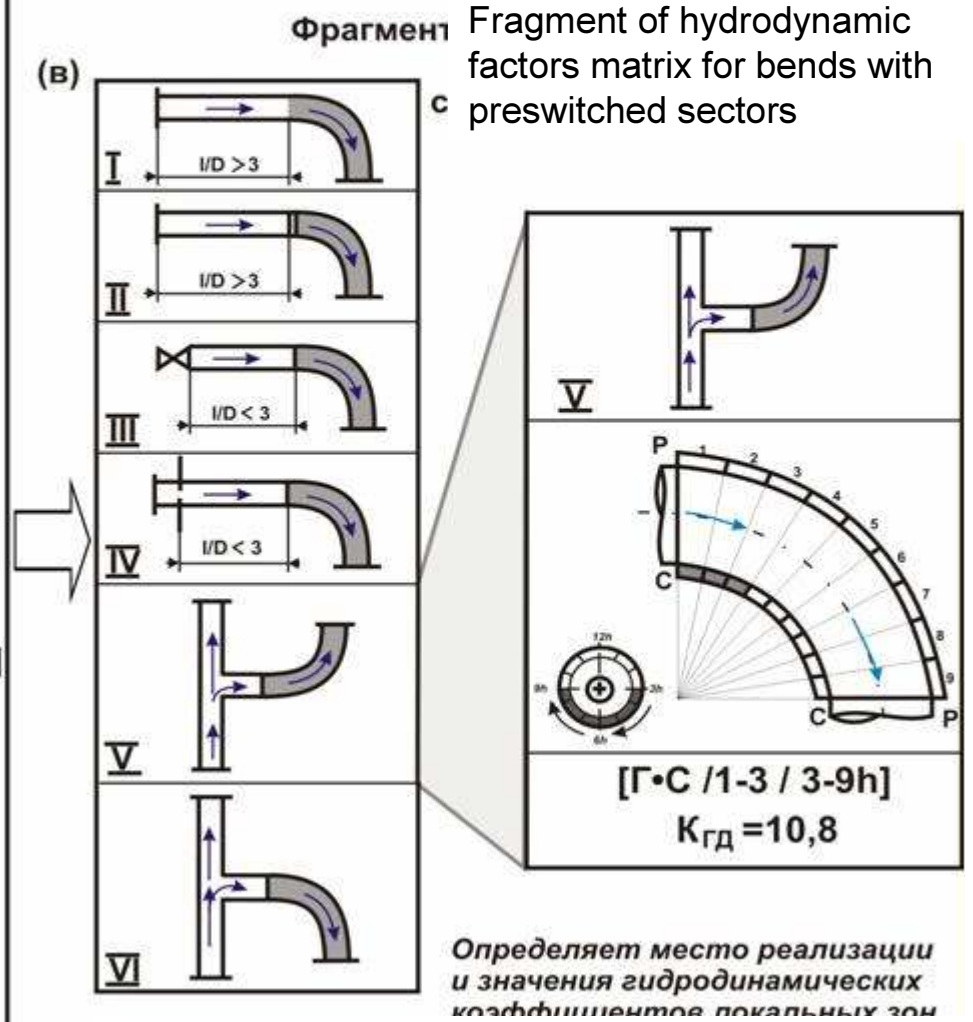
From Ineffective Geometry Factor to Matrix of Hydrodynamic Factors and Location Areas of Local Metal Thinning

ATPE-9-03 Regulations



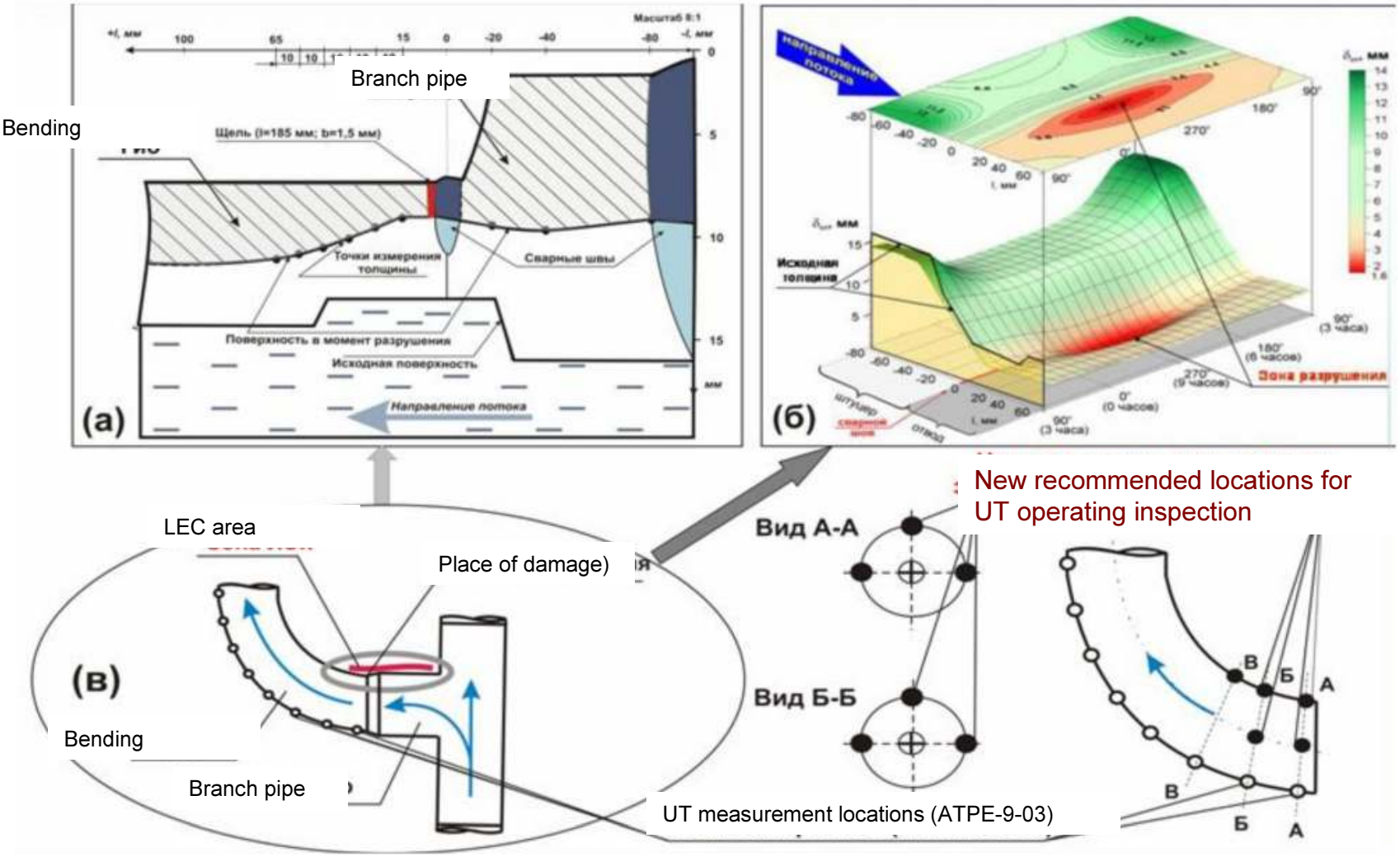
1. Do not consider role of preswitched sector
2. Do not indicate areas of active local EC thinning

Fragment of hydrodynamic factors matrix for bends with preswitched sectors

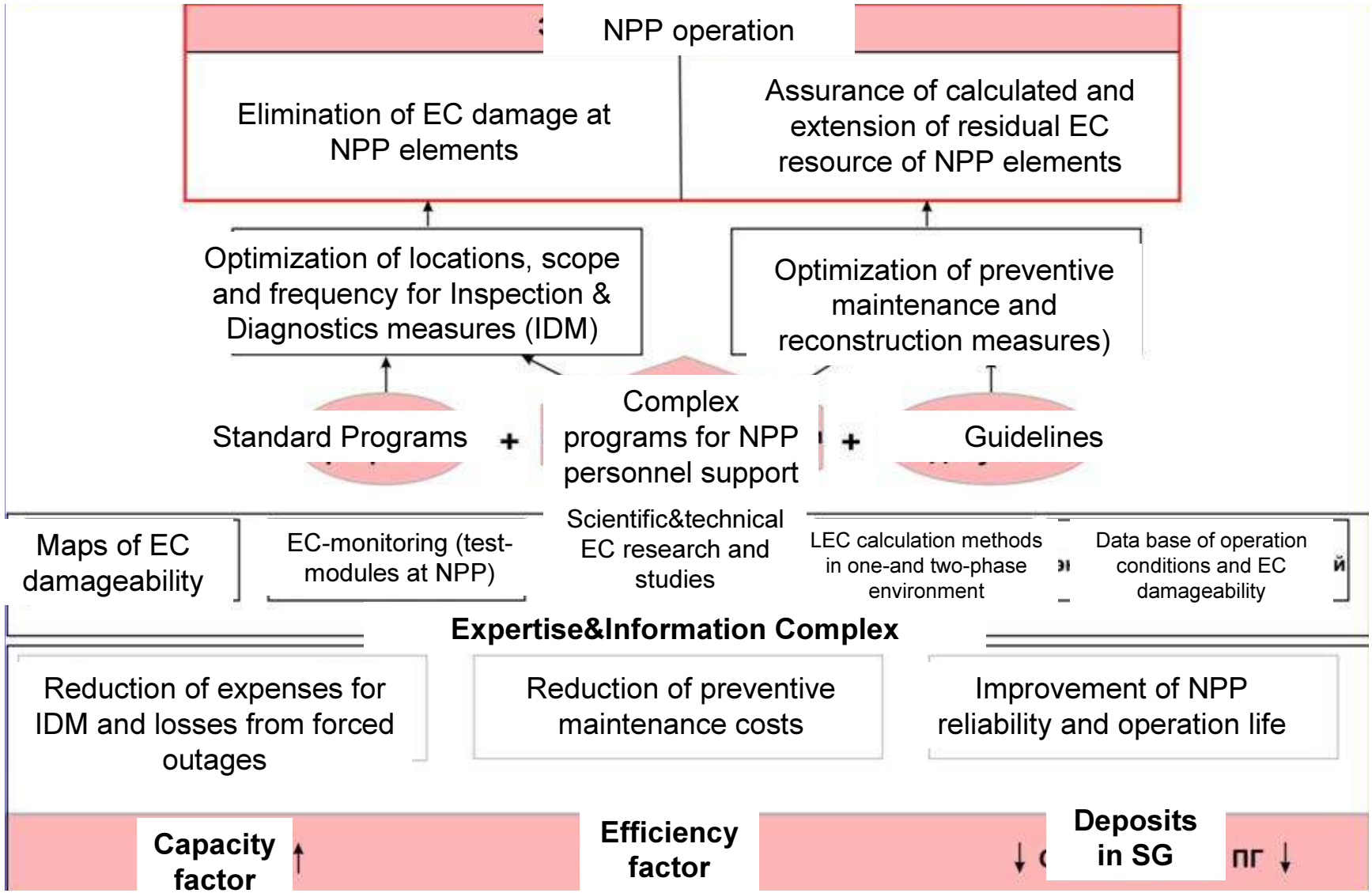


Define location and values of hydrodynamic factors for local areas with active EC thinning considering preswitched sectors

Calculation- Experimental Justification of UT Operating Inspection in Locations not included into Industrial Standard Programs based on Example of Inlet Section of Environment Supply Control Bypass Unit: real wall thinning (а) and results of calculation modeling by RAMEK activity of local erosion-corrosion (б) damaged unit «bending-branch pipe» (в)



Concept of Complex Program Implementation Consisting Measures on Damage Prevention and Erosion-Corrosion Resistance Improvement of NPP Pipelines Elements and Components



Concept of Work on Complex Program of Measures on Damage Prevention and Erosion-Corrosion Resistance Improvement of NPP Pipelines Elements and Components № AES PRG-550-K07