

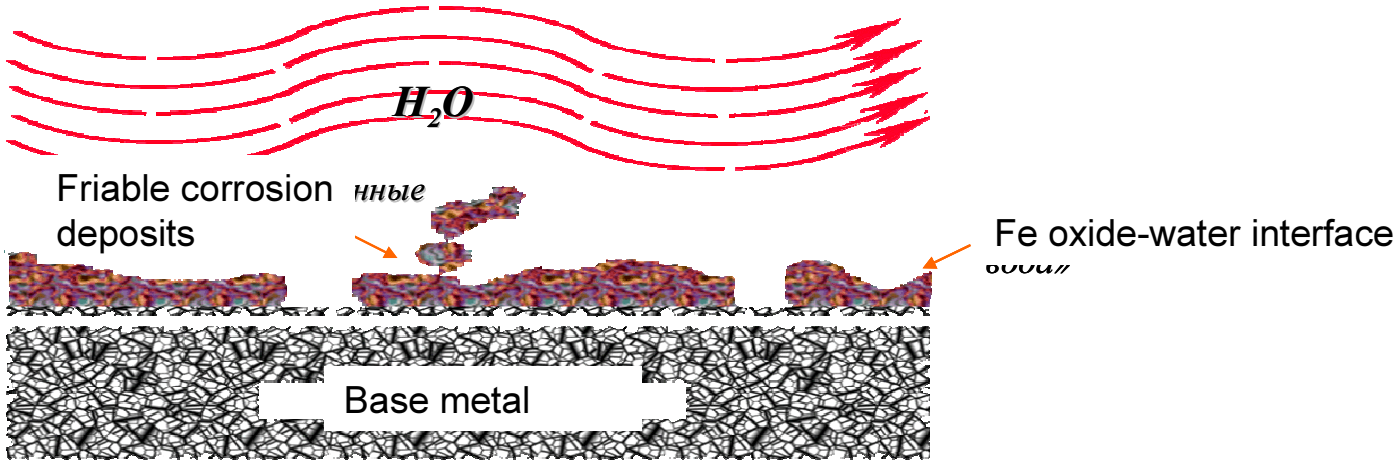
STATE SCIENTIFIC CENTER  
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**Methodical aspects of studies of a multifactor E/C process with assessment of the external factors influencing on the corrosion phase of the process and the uncertainties related to the nature and degree of damage while performing diagnostics by ultrasonic methods**

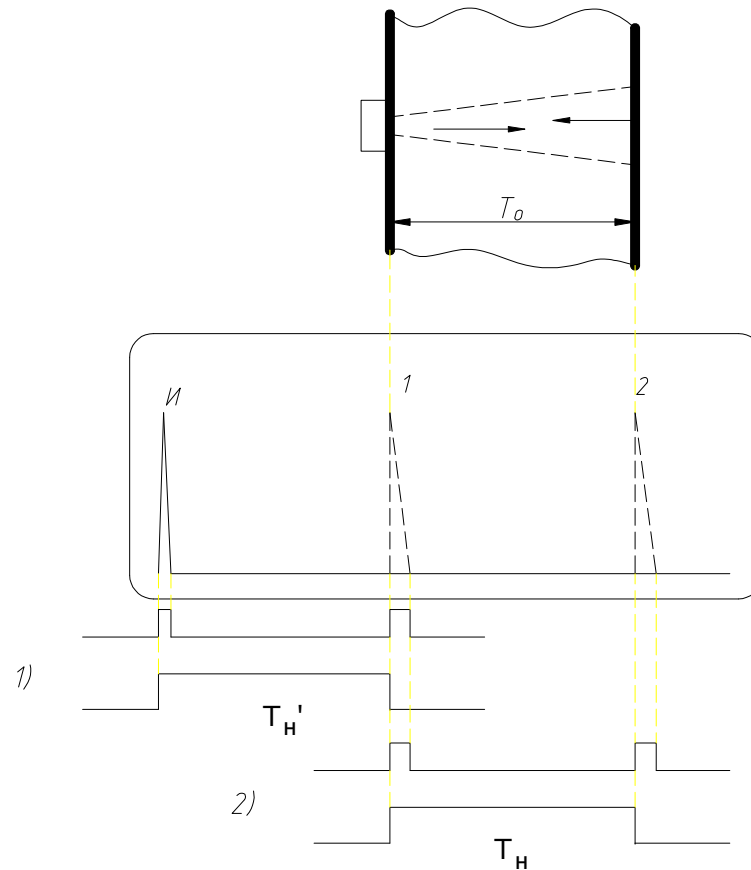
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# SIMPLIFIED SCHEME OF EROSION-CORROSION PIPELINE WEAR



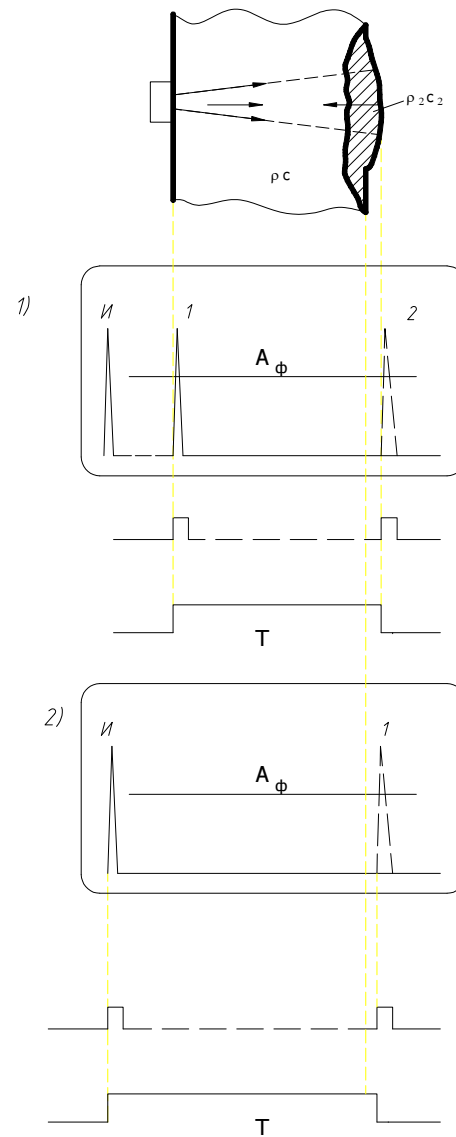
# Scheme of Wall Thickness UT Inspection

## 1. Thickness inspection of metal without EC deposits



Here: Ultrasound reflection from free surface in homogenous metal with known density and ultrasonic speed.

## 2. Thickness inspection of metal with EC deposits



**Here: Ultrasound reflection from a surface with unknown acoustic parameters:  
substance density and ultrasonic speed inside it.**

What does UT inspection show?!

## Properties of Fe corrosion products

Composition	Color	Density, g/cm <sup>3</sup>	Thermal stability
Fe(OH) <sub>2</sub>	White	3,4	Decomposes at 100°C to Fe <sub>3</sub> O <sub>4</sub> & H <sub>2</sub>
FeO wustite	Black	5,4-5,73	Melts at 1371-1424°C, lower than 570°C decomposes to Fe & Fe <sub>2</sub> O <sub>3</sub>
Fe <sub>3</sub> O <sub>4</sub> magnetite	Black	5,2	Melts at 1597°C
α-FeOOH, goethite	Yellow	4,2	Dehydrates to α-Fe <sub>2</sub> O <sub>3</sub> at 200°C
β-FeOOH	Light brown	-	The same at 230°
γ-FeOOH lepidocrocite	Orange	3,97	Dehydrates to Fe <sub>2</sub> O <sub>3</sub> at 200°C
β-Fe <sub>2</sub> O <sub>3</sub> maghemite	Brown	4,88	Turns into Fe <sub>2</sub> O <sub>3</sub> at 250°C
α-Fe <sub>2</sub> O <sub>3</sub> haematite	Brick-red to black	5,25	Decomposes to magnetite at 1457°C & 100кПа

Ultrasound speed in EC deposits = ? (unknown)

**We cannot establish the thickness of residual metal in damaged area with EC deposits!!!**

This physical explanation proves relevancy of prof. V.I. Baranenko studies results:  
-UT inspection gives numerical values lower as well as higher than nominal thickness





Discontinuities similar cracking from hot  
(Bal NPP) and cold (KlnNPP) headers

Balakovo NPP

Kalinin NPP

Балаковская АЭС

КОЛЛЕКТОРОВ

Калининская АЭС



x10

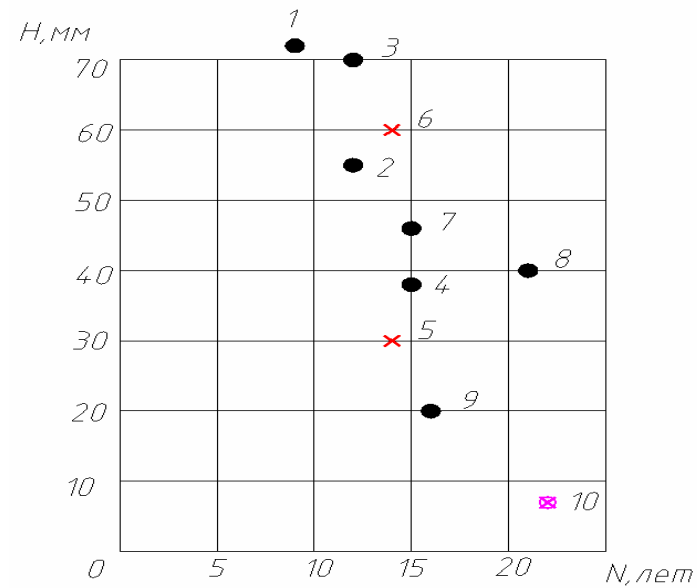


x25

ЗДКР  
SSSCC

Pitting corrosion

## Relation between the damage size and SG operation period

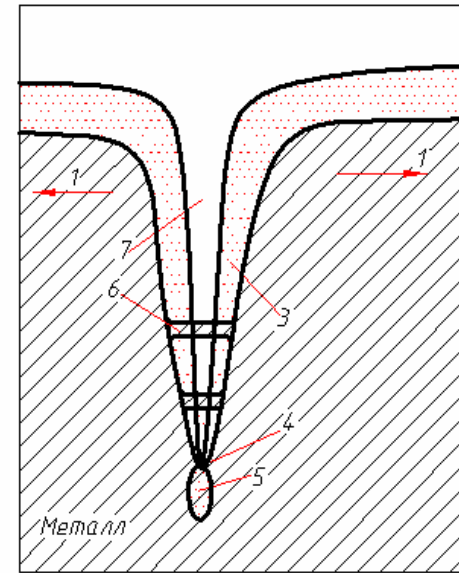
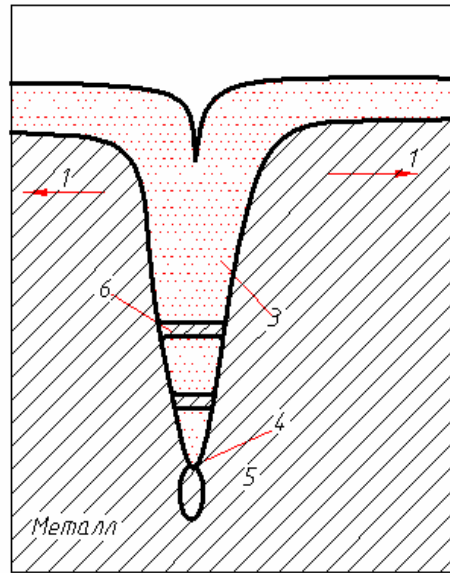
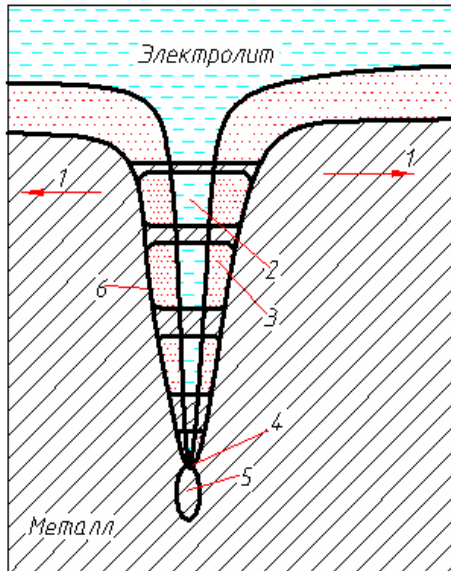


**H,mm – cracking size at the moment of detection**

**N,years – term of SG operation from the beginning to the moment of cracking detection**

- -longitudinal and longitudinal-transverse cracks
- × -transverse cracking
- ⊗ -pitting corrosion

## Possible state of damage in header-steamgenerator connecting joint



- 1 – direction of tension stress;
- 2 – metal damage filled with electrolyte;
- 3 – protection film;
- 4 – active metal at the top of cracking;
- 5 – sector of maximum stress concentration;
- 6 – metal bridge remained between damage sides

## CONCLUSIONS

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1. It is assumed that corrosion deposits interaction mechanism in pipelines subjected to EC and damages of slow strain-rate stress corrosion cracking (SSSCC) interact with ultrasonic waves in the same way.

This fact determines the quality of UT thickness and SSSCC cracking detection.

2. What we assume to do to improve UT thickness quality in pipelines subjected to EC?

- - UT inspection studies with different oxide films and predefined structure state (continuous and adhesion with base metal).
- - Studies of different inspection methods: longitudinal and transverse waves: direct and inclined wave inputting at different frequencies.
- Criteria of validity: comparison of UT thickness measurement results and metallography together with gravimetric method of wall thinning evaluation.