РОСАТОМ

НИИП

Cable qualification at NPPs: Certification and diagnostics

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FSUE “RISI” as the test centre for the State Corporation “Rosatom”

- Provides technical support to Rosenergoatom Concern OJSC
  - Diagnostics and state monitoring
    - Electric equipment (EE)
    - Power and instrumentation cables
  - Development and implementation of residual life management programs
  - EE and cable qualification tests for NPPs

Cable qualification at NPPs

- Assessment of cable technical state at NPPs is carried out on the basis of:
    - Results of typical certification tests
    - In-service technical diagnostics of representative cables
- The main technical document «Assessment of the technical condition and ageing management of cables in nuclear power stations»

  ПО 1.2.1.02.999.0184-2013

Открытое акционерное общество
«Российский концерн по производству электрической и тепловой энергии на атомных станциях»
(ОАО «Концерн Росэнергоатом»)

УТВЕРЖДАЮ
Заместитель Генерального директора - директор по производству и эксплуатации АЭС
__________ А.В. Шутиков
«__» __________ 2013

ОПРЕДЕЛЕНИЕ ТЕХНИЧЕСКОГО СОСТОЯНИЯ И УПРАВЛЕНИЕ СТАРЕНИЕМ КАБЕЛЕЙ НА АТОМНЫХ СТАНЦИЯХ

ПОЛОЖЕНИЕ

ПО 1.2.1.02.999.0184-2013

Открытое акционерное общество
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ПРИКАЗ

05.02.2014 № 9/105-П

Москва

О введении в действие
ПО 1.2.1.02.999.0184-2013

В целях повышения надежности эксплуатации электротехнического оборудования АЭС ОАО «Концерн Росэнергоатом»

ПРИКАЗЫВАЮ:

1. Ввести в действие с 28.03.2014 ПО 1.2.1.02.999.0184-2013 «Определение технического состояния и управление старением кабелей на атомных станциях. Положение» (далее - ПО 1.2.1.02.999.0184-2013, приложение).

2. Заместителям Генерального директора - директорам филиалов ОАО «Концерн Росэнергоатом» - действующих атомных станций и руководителям структурных подразделений центрального аппарата ОАО «Концерн Росэнергоатом» принять ПО 1.2.1.02.999.0184-2013 к руководству и исполнению.

3. Департаменту планирования производства, модернизации и продления срока эксплуатации (Дементьев А.А.) внести в установленном порядке ПО 1.2.1.02.999.0184-2013 в подраздел 2.4.1 части III Указателя технических документов, регламентирующих обеспечение безопасной эксплуатации энергоблоков АС (обязательных и рекомендуемых к использованию).

4. Департаменту инженерной поддержки (Давиденко Н.Н.) обеспечить координацию работ по внедрению ПО 1.2.1.02.999.0184-2013.

5. Контроль за исполнением настоящего приказа возложить на заместителя Генерального директора - директора по производству и эксплуатации АЭС Шутикова А.В.

Генеральный директор Е.В. Романов

С.Е. Бондарчук
(499) 277-23-31 (доб. 402)

Rosenergoatom basic technical documents for cable residual life management (RLM)

- MP 1.2.1.13.1037-2015. “Diagnostics of technical state and residual life time of I&CS cables important for safety at NPPs
- MP 1.2.1.13.0018-2011. “Guidelines on diagnostics of defects in instrumentation cables at nuclear plants”
- ТПРГ 1.2.6.9.0072-2011. “Generic program for cable lines diagnostics at nuclear plants. Requirements and guidance on development and implementation”
- MP 1.2.02.0168-2013. “Diagnostics of technical state of power cables with impregnated paper insulation at nuclear plants”
- MP 1.2.1.13.1005-2015. “Overall diagnostics of technical state of power cables 6-10 kV with cross-linked polyethylene insulation”

Utilization of international experience

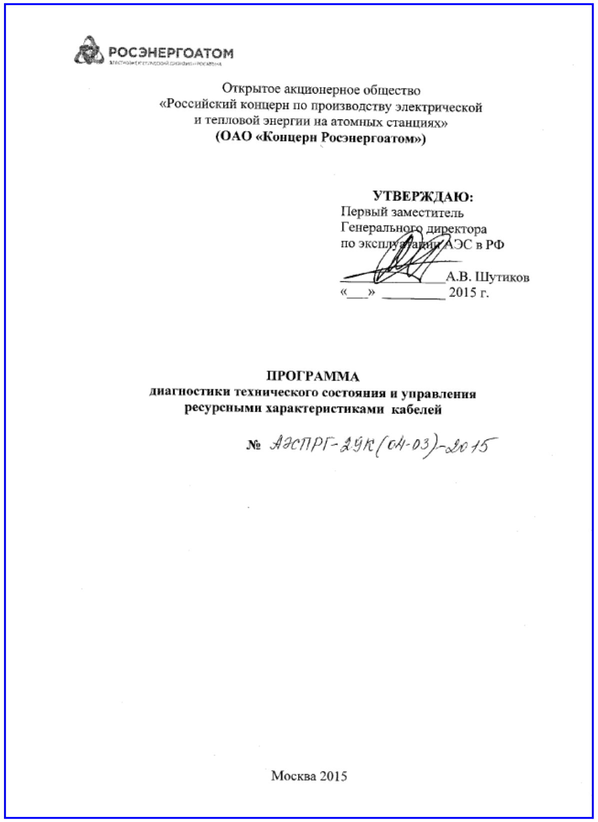
- Equipment Qualification in Operational Nuclear Power Plants: Upgrading, Preserving and Reviewing. Safety reports series №3. – Vienna: IAEA, 1998
- IAEA-TECDOC-1188. Assessment and management of ageing of major nuclear power plant components important to safety: In-containment instrumentation and control cables, Volume 1-2, ISSN 1011-4289. – Vienna: IAEA, 2000
- IAEA-TECDOC-1147. Management of ageing of I&C Equipment in Nuclear Power Plant. – Vienna: IAEA, 2000
- IAEA-TECDOC-1402. Management of life cycle and ageing at nuclear power plants: Improved I&C maintenance, ISSN 1011-4289. – Vienna: IAEA, 2004

Ageing management for nuclear power plants: safety guide. IAEA Safety Standards, no. NS-G-2.12. – Vienna: IAEA, 2009

Assessing and Managing Cable Ageing in Nuclear Power Plants, No.NP-T-3.6, Vienna: IAEA, 2012

Implementation of measures on cables qualification

- Implementation of programs
  - – diagnostic programs (a general program of the Concern and private NPP's programs)
  - – ageing management programs (AMP) of NPP's elements
  - – maintenance programs
- Doers
  - – electrical and I&C workshops staff
  - – technical support organizations' staff



РОСЭНЕРГОАТОМ

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УТВЕРЖДАЮ:
Первый заместитель
Генерального директора
по эксплуатации АЭС в РФ
__________ А.В. Шутиков
«___» _________ 2015 г.

ПРОГРАММА
диагностики технического состояния и управления ресурсными характеристиками кабелей

№ АЭСПРГ-29К(04-03)-2015

Москва 2015

Main residual life characteristics of cables

- Service life (warranty, specified, certified, rated)
- (Technical) state indicators
- Initial and limiting values of the condition indicators
- Ageing curve (ageing model)
- Resistance to the design-basis external influencing factors (EIFs)

Cable RLM activities objective is to identify and periodically update the main residual life characteristics

Basic elements of cable RLM activities at NPPs

- Determination of cable resistance to design-basis external influencing factors (EIFs) and harsh environment conditions of operation (“hot spots”)
- Identification of prevailing ageing mechanisms and effects
- Implementation of measures aimed at reduction of EIF strength
- Execution of diagnostics (monitoring) of technical state and regular assessment of residual life
- Development and implementation of new non-destructive methods for diagnostics (monitoring)
- Comparison of costs of cable removal from service with their replacement with costs of routine certification
- Well-timed replacement of cables with limiting state reached at power units
- etc.

Basic elements of cable RLM activities at NPPs (cont'd)

Planning

2. Coordination of the activities as part of cable residual life management
–Maintenance optimization
–Operating experience transfer
–Research & Development
–Technical support
–Requirements to reliable operation under impact of design-basis EIFs and "hot spot" operating conditions

RLM programme modification

Mitigation of ageing effects

Technical measures applied to cables

5. Operability maintaining
–Cable certification in line with modern requirements
–Alteration of cable routes
–Searching and elimination of defects along routes
–Replacement of aged cables
–Witness cable laying

1. Cable ageing mechanism knowledge *(the key to residual life management)*
–Insulating materials and their properties
–Operating conditions
–Main ageing mechanisms
–Localization of operating "hot spots"
–Specific condition indicators
–Ageing impact on functional parameters
–Operating experience
–Results of scientific studies

Preventing measures

3. In-service management of ageing mechanisms
–Operating condition monitoring (temperature, radiation humidity, etc.)
–Adjustments to compensate steam leaks, water leaks, etc.
–Maintenance of ventilation, thermoinsulation, etc. systems
–Reduction of operating "hot spots"

Tests

4. Cable state diagnostics and monitoring *(detection and assessment of ageing effects)*
–Visual examination
–Standard tests
–ND diagnostics and state monitoring of representative cables
–Assessments and comparison with certification test results

Determination of feasibility, term and conditions of further operation

Technical condition monitoring

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Cable qualification methodology for NPPs

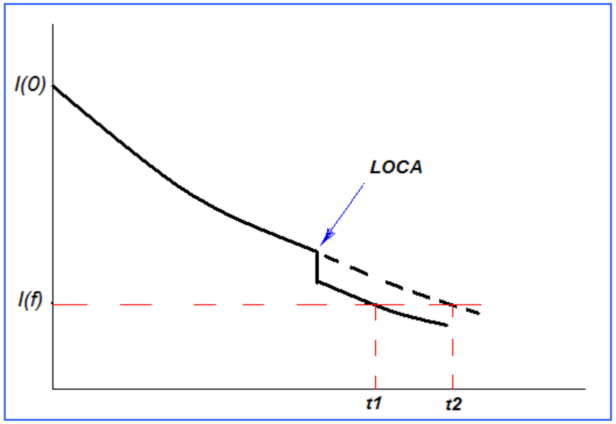
- The main goal of qualification is to provide sound evidences of cable operability under impacts of external influencing factors (EIFs) in operation during a specified service life
  – First stage – performance of certification tests for new cable types on resistance to EIFs under both normal operation and design basis accident conditions, in order to define a certified service life
  – Second stage – ongoing qualification of cables in service at a nuclear power unit. The ongoing qualification goal is to extend the certified service life to a new time period, on the basis of operating experience analysis and conduction of periodical diagnostics (monitoring) of representative cables
- An alternative for the ongoing qualification would be:
  – cable replacement, or
  – repeated conduction of generic certification tests

Generic certification tests for defined operating conditions

- In course of typical qualification tests, cable degradation is artificially simulated:
  - – for normal operating conditions (as per design) during the specified service life;
  - – under impact of damaging factors for design basis accidents;
  - – under impact of post-accident environment
- It is recommended to plan and perform the generic qualification tests for several time periods in parallel (e.g. for 25, 30, 35, 40 years)

Tests for resistance to design basis accidents

- under development of new elements
- under lifetime extension of nuclear units

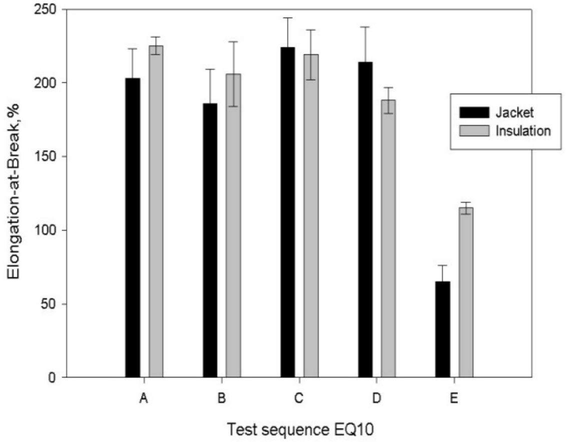


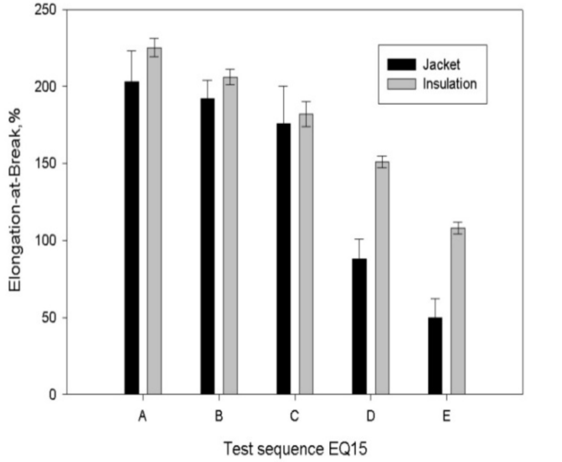
Accident parameter	HELB	LOCA	Loss of heat removal from a containment	Minor break
Temperature, °C	104	to 150	30 to 75	to 90
Pressure, kgf/cm^2	1,2	to 5,0	от 0,05 до 0,12	to 0,17
Humidity, %	100	steam-air mixing	to 100	steam-air mixing
Activity, Bq/m^3	-	to $9{,}3 \cdot 10^{13}$	$7{,}4 \cdot 10^7$	to $5{,}5 \cdot 10^9$
Absorbed dose rate, Gy/h	-	to 10^3	to 1,0	to 1,0
Mode duration, h	to 1	to 10	to 15	to 15
Post-accident temperature, °C	15 – 50	20 – 60		20 to 60
Post-accident pressure, kgf/cm^2	-	0,51 – 1,22		0,05 to 0,12
Post-accident conditions duration	-	to 30 days	to 15 hours	to 5 hours
Frequency of occurrence	once within a lifetime	once within a lifetime	once a year	twice a year

Traditional technical parameters of cables and associated acceptance criteria

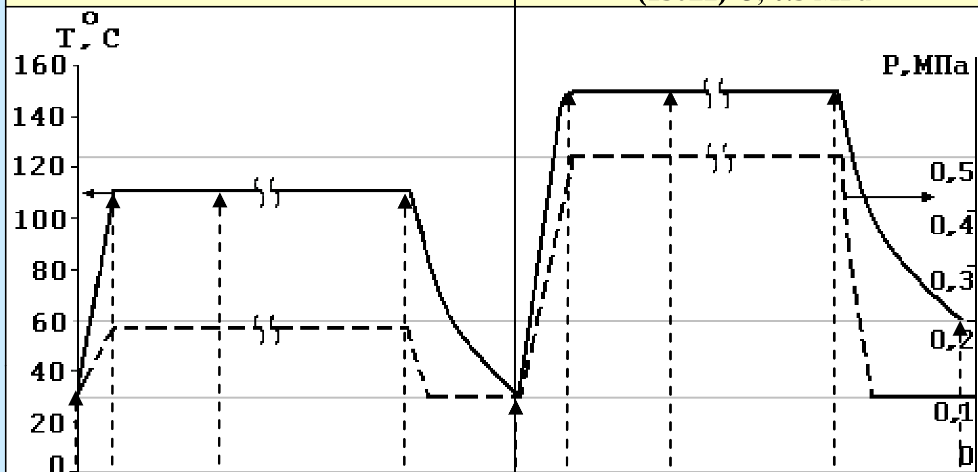
Parameter	Cable type	Acceptance criteria		
		New cable	After artificial ageing	In course of, and after the test with simulation of design basis accident
Ultimate elongation	All types	Shall meet specification requirements	>50% of absolute value [1]	>50% % of absolute value
Flexural resilience test изгибе	All types	No insulation cracks	No insulation cracks	No insulation cracks
Dielectric strength test	All types	Test passed successfully	Test passed successfully	Test passed successfully
Insulation resistance	All types	Shall meet specification requirements or design documentation	Shall meet specification requirements reduced by an order of magnitude, or design documentation	Shall meet specification requirements reduced by four orders of magnitude. The cable shall continue to perform its functions
Electric capacity	Communication cables	No changes	No changes	No changes
Attenuation coefficient , Characteristic impedance, Interference elimination Signal propagation	Coaxial	No changes associated with technical characteristics	No changes associated with technical characteristics	No changes associated with technical characteristics [2]
Another parameter		Depends on specificity of the cable application (e.g. absence of liquid or steam in the cable during tests with design basis accident simulation)		

N o t e s
1 For some cables, a value less than 50% of absolute length may be applied
2 Only those changes are acceptable which are provided for by the NPP design or a relevant standard, like attenuation coefficient increase due to temperature elevation.



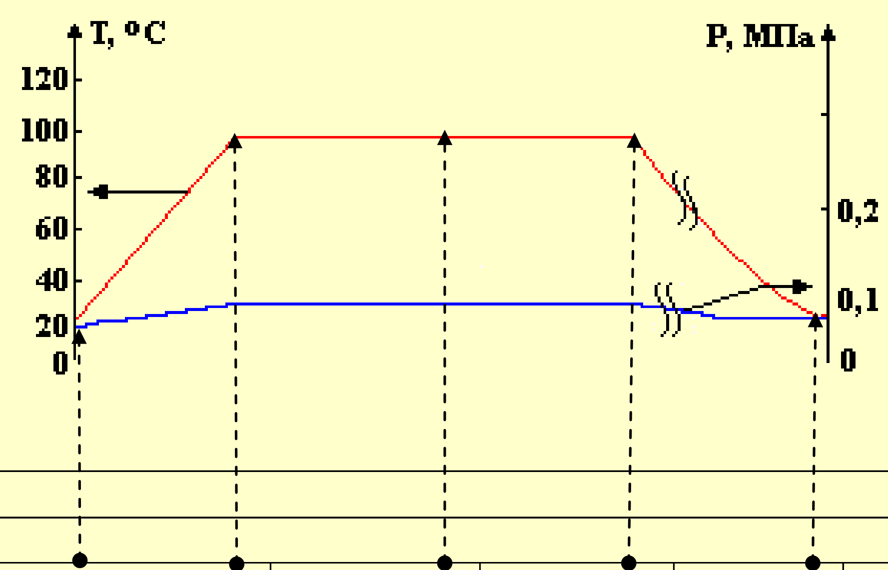


Certification test plan (minor leakage + LOCA)

Order / Operation (Test stages)	Thermal-induced ageing: before	Thermal-induced ageing: after	Radiation-induced ageing: before	Radiation-induced ageing: after	Measurements prior to steam test	"Small leak" mode (0.5·*N* cycles × 5 h) (115±2)°C; 0.170 MPa / "Large leak" mode (1 cycle × 24 h) (150±2)°C; 0.5 MPa	Measurements after steam test	Radiation-induced ageing: before	Radiation-induced ageing: after	Holding in decontaminating solution 7 days under 60 °C and pressure 0.1 MPa
										
Equipment check	X		X					X		
Visual examination		X			X		X			X
Insulation resistance measurement	X	X		X		0; 0.5 h; 4 h; X h; X+5 h; 10 minн; 4 h; 12 h; 24 h	X		X	X
EAB measurement	X	X		X			X			X
CI measurement	X	X		X			X			X

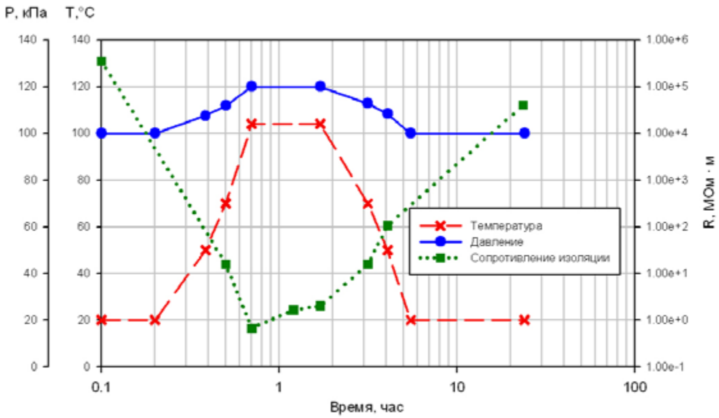
Stages of generic tests of in-containment cables and thermodynamic profiles of temperature and pressure in accident conditions, for VVER-1000 model 320 design (here *N* is a specified service life for cables, in years)

Certification test plan (HELB)

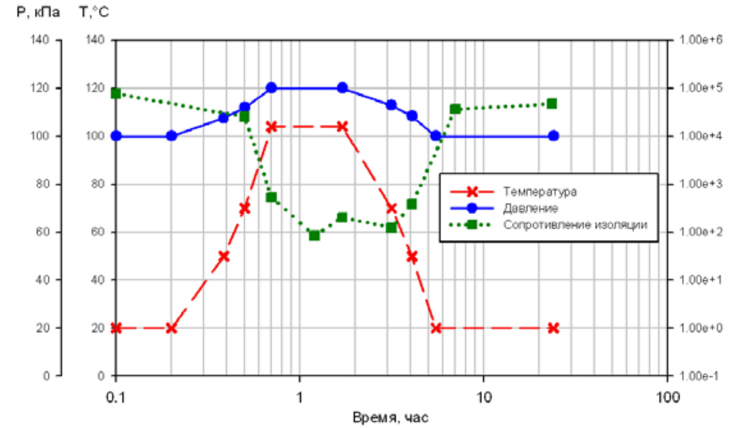


Order / Operation	Test stages: Thermal-induced ageing, before	Thermal-induced ageing, after	Measurements prior to steam test	HELB, 1 hour; (104 ± 2) °C; 0,12 MPa	Measurememts after steam test
Equipment check	X				
Visual examination		X	X		X
Insulation resistance measurement	X	X		0,0; 0,5 h; 1,0 h; 1,5 h; 5 h	X
Functional test	X	X	X	X	X
Measurement with intender (for cables)	X	X			X
EAB measurement (for cables)	X	X			X

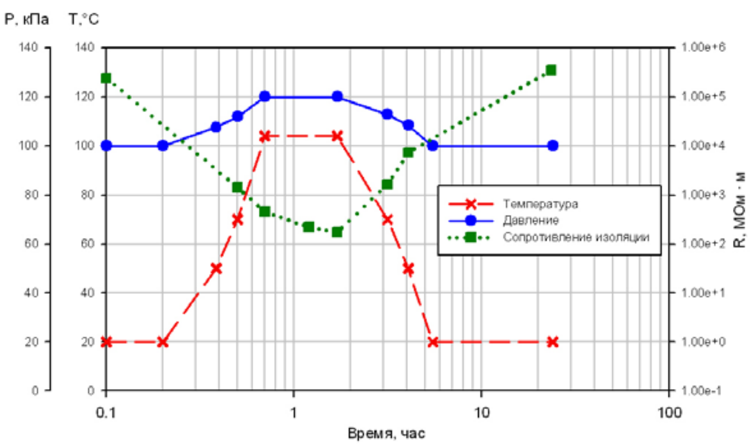
Tests for resistance to high-temperature air-steam mixing: cable samples from Balakovo and Kozloduy NPPs



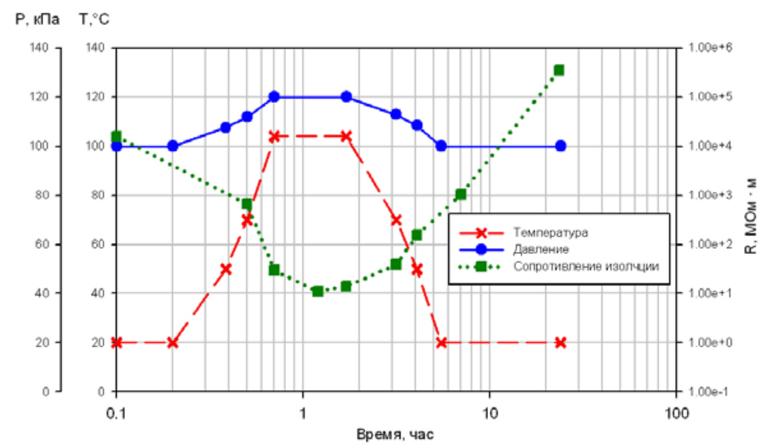
$R_{ИЗ}$ образца кабеля КВВГЭ 4×2.5 во время воздействия высокотемпературной парогазовой смеси. Образец изъят с первого блока после 25- летней эксплуатации



$R_{ИЗ}$ образца кабеля КВВГЭнг 4×1,5 во время воздействия высокотемпературной парогазовой смеси. Образец был изъят с первого блока после 25- летней эксплуатации и дополнительно состарен на 10-летний дополнительный срок службы

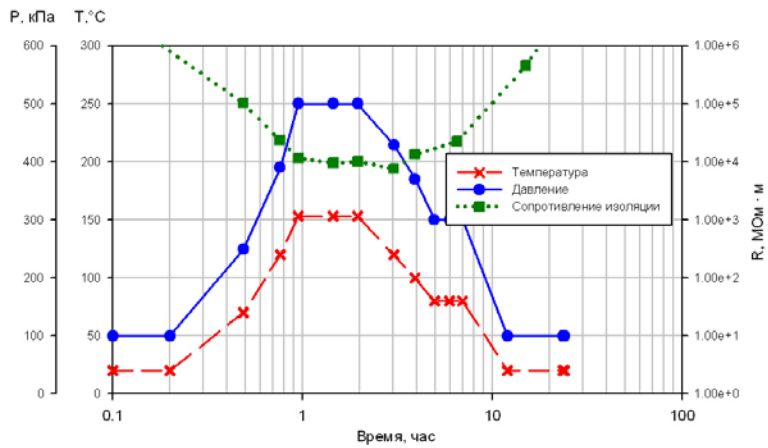


$R_{ИЗ}$ образца кабеля КУГВЭВнг 24×0,35 во время воздействия высокотемпературной парогазовой смеси. Образец изъят с первого блока после 25- летней эксплуатации

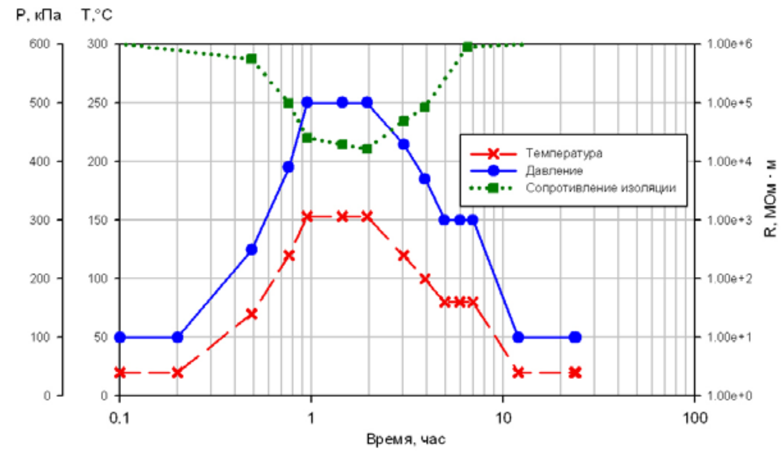


$R_{ИЗ}$ образца кабеля КУГВЭВнг 24×0,35 во время воздействия высокотемпературной парогазовой смеси. Образец был изъят с первого блока после 25- летней эксплуатации и дополнительно состарен на 10-летний дополнительный срок службы

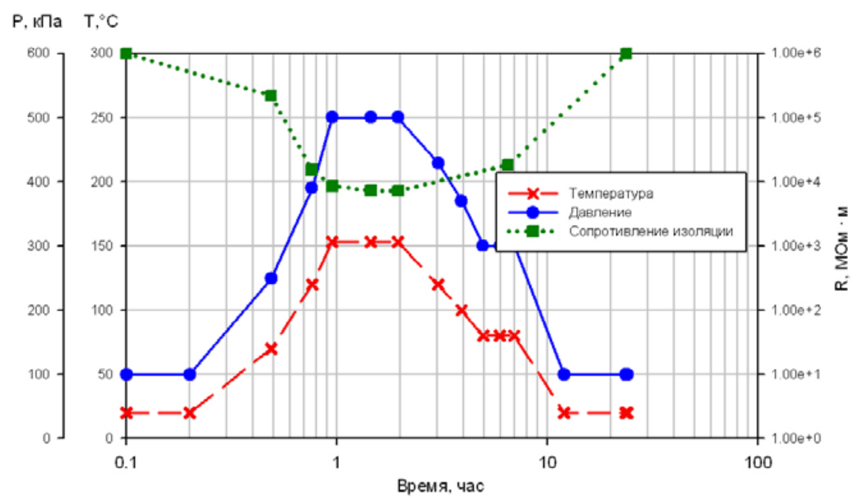
Tests for resistance to high-temperature air-steam mixing: cable samples from Balakovo and Kozloduy NPPs (cont.)



$R_{ИЗ}$ образца кабеля КПЭТИ 7Х2Х0,35 во время воздействия высокотемпературной парогазовой смеси. Образец изъят после 25-летней эксплуатации

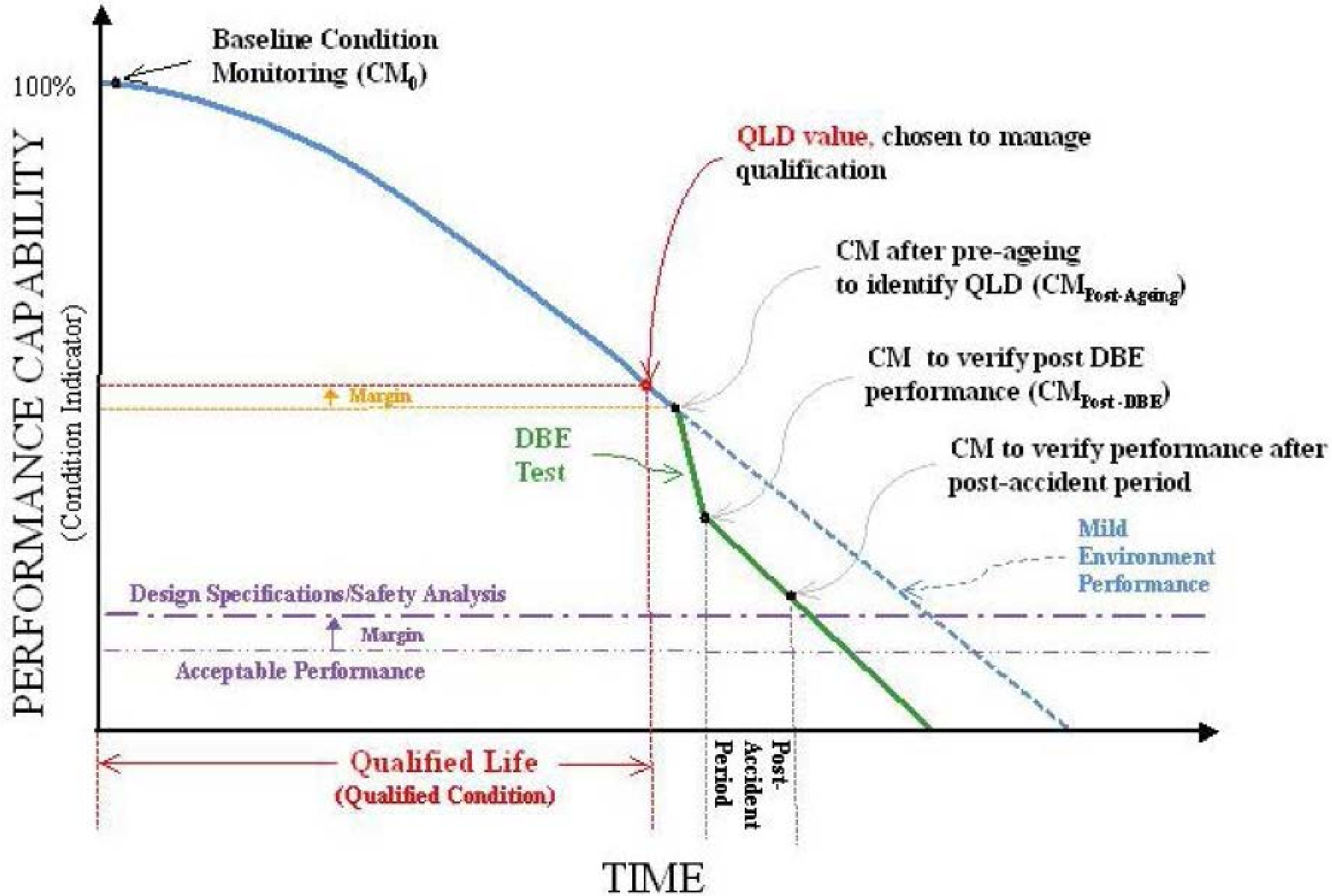


$R_{ИЗ}$ образца кабеля КПЭТИ 7×2×0,35 во время воздействия высокотемпературной парогазовой смеси после предварительного старения на 10 лет эксплуатации. Образец изъят после 25- летней эксплуатации



$R_{ИЗ}$ образца кабеля КПоБОВ14х2,5 во время воздействия высокотемпературной парогазовой смеси. Образец изъят после 18 -летней эксплуатации с признаками предельного состояния по показателю ТНО

Operability assessment. Condition indicators



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Selection of test parameters and specimens

- 3 to 5 specimens not longer than 3 m and additional short specimens for measurements of mechanical properties
- $t_{test\text{-}1.} = t_{exp.} \cdot exp[(E_a /k)\cdot(1/T_{test\text{-}1.} - 1/T_{exp.})]$ – the thermal-induced ageing time (estimation as per Arrhenius law)
- Problems with determination of E_a
- $t_{test\text{-}2.} = (D_{exp.} + D_{accid\text{-}2})/P_{test.}$ – the radiation-induced ageing time, P ≤ 500 Gy/h (P ≤ 100 Gy/h in case of existence of a synergetic effect)

Conservatism and uncertainties in generic tests

- In the accelerated tests it is impossible to apply an ageing mechanism in full scale due to high intensity of the influencing factors
- The main cause of the conservatism introduced is application of the Arrhenius model
- Simulation of multifactor ageing in the accelerated tests (separate / simultaneous impact / sequence of impacts)
- Addressing other EIFs, including the ones not included in the design basis
- Errors of EIF strength simulation associated with the testing equipment. Typical tolerances are:
  - maximum temperature: +8 ^{o}C
  - maximum pressure: ±10% of sensor readings
  - absorbed dose: ±15% of dosimeter readings
  - power source voltage: ±10% of voltage readings

Principal RLM activities for cables in service

- Cable service condition monitoring
- Identification of representative cables and identification of cable routes in harsh operating environment (“hot spots”)
  - ❑ The cables which are comprehensively characterize the ageing of cables of a certain type, with the same conditions of their installation, the same external factors influencing over all parts of cable routes, and the same operating modes
- **Diagnostics** (monitoring) of conditions of the representative cables on the basis of condition indicators, including specimens of witness cables
- Implementation of measures aimed at reduction of EIF strength
- Cable repairing and replacement as per schedule

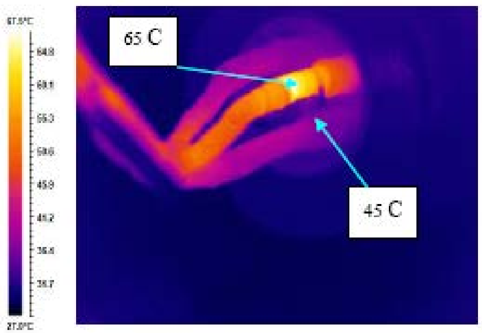
Assessment of current certified status of cables

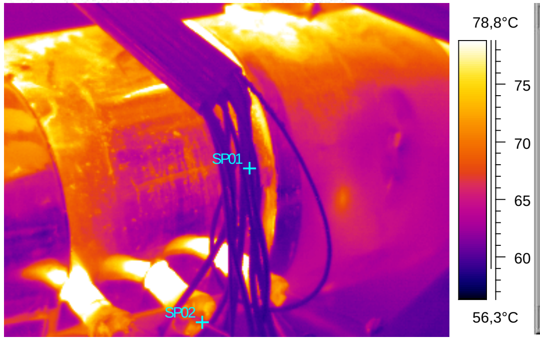
- The EQ1 cables are those with certified service life T_{eq} not less than the additional operating life T_{newpr} for the power unit plus residual operating life as per design T_{respr}: $T_{eq} \geq T_{newpr} + T_{respr}$
- The EQ2 cables are those with T_{eq} less than $T_{newpr} + T_{respr}$, but not less than the current operating life T_{cur} for the power unit
- The EQ3 cables are those with $T_{eq} \leq T_{cur}$
- The EQ4 cables are those with unconfirmed certification status

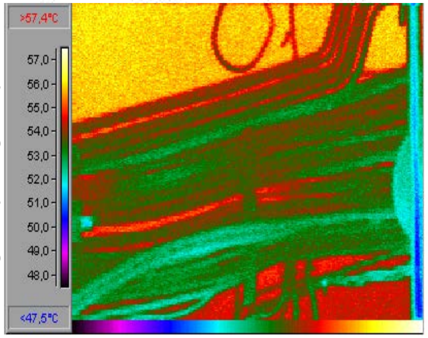
– Cables can be transferred to another class (e.g. from EQ4 to EQ1 class) provided that positive results are obtained in generic certification tests or their certified status is confirmed by documents

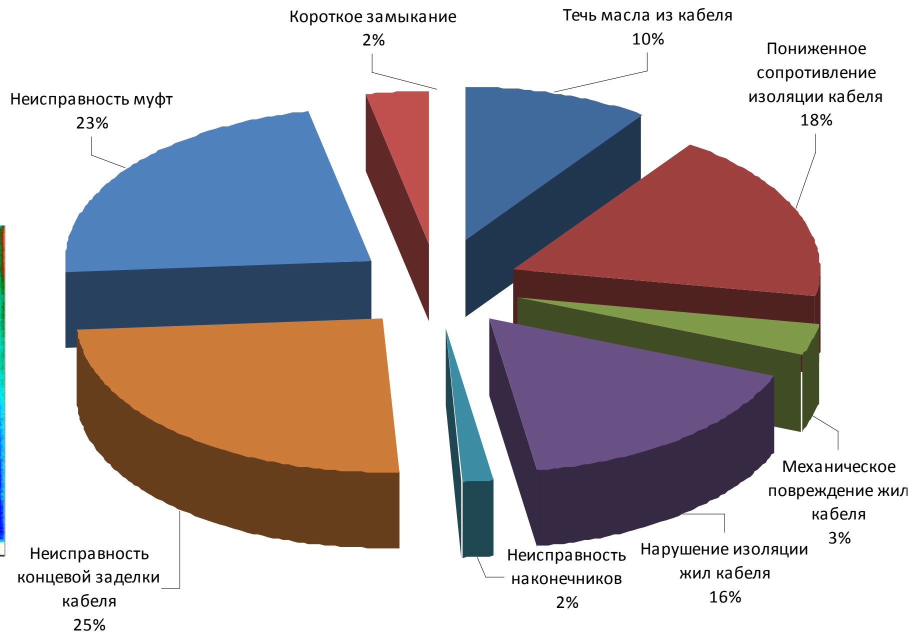
Technical examination of cable routes

- Visual and tactile examination
- Thermovision monitoring
- Questioning the personnel
- Review of operating documentation









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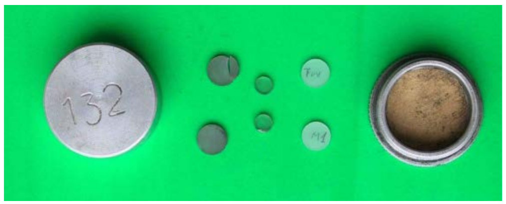
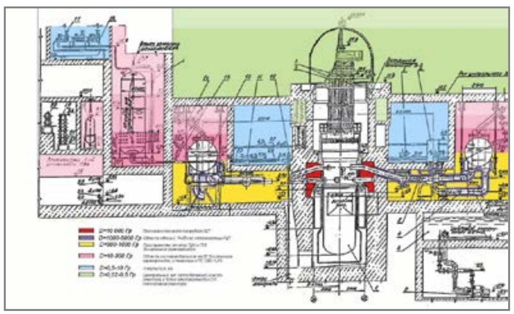
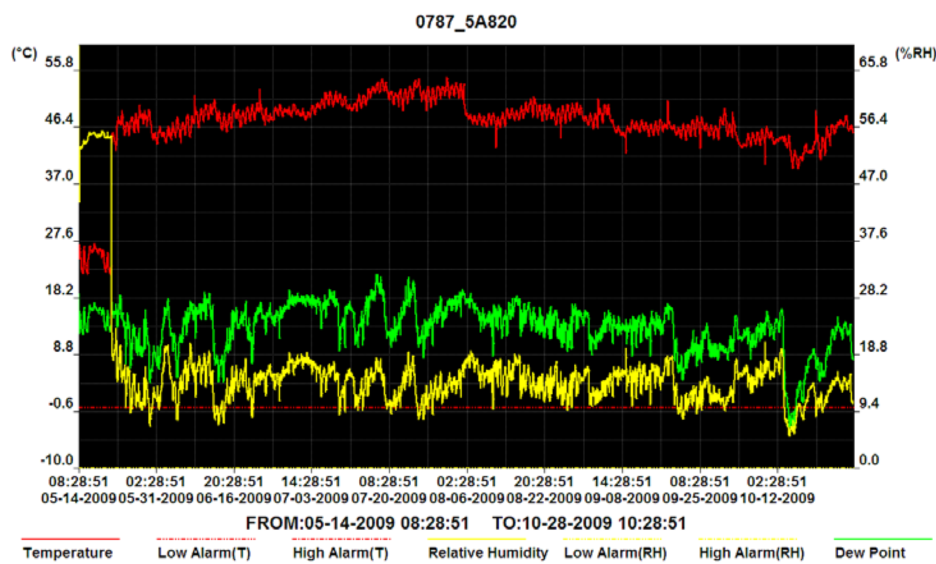
Temperature and radiation monitoring





- were used: 1) assembly of 2 thermoluminescent dosimeter; 2) analysis of data from standard sensors
- actual radiation level did not exceed design basis level



Non-destructive diagnostic methods

- Can be arbitrarily divided onto two groups
  - The methods allowing to evaluate the extent of insulation ageing due to their high sensitivity *(determination of antioxidant and stabilizer concentrations, measurements of recovery voltage, isothermal relaxation current, tgδ in the range 0.001 to 1000 Hz,…)*
  - The methods which does not provide a high sensitivity to ageing, but allow to locate (preliminary determine the location) the defects already developed along the cable routes *(time-based reflectometry, partial discharge reflectometry, bridge methods ,…)*

Methods of diagnostics

Method	Condition monitoring and service life determination	Defects localization over the route
Ultimate elongation measuring for cable insulation materials	Yes, main destructive method	No
Measurement of insulation resistance R_{in} and absorbing properties K_a and PI	Yes, low sensitivity	No
Detection of gel fraction	Yes, ageing monitoring through counting the number of joinings	No
Density measurement	Yes, ageing monitoring by density value	No
Nuclear magnetic resonance (NMR)	Yes, ageing monitoring by NMR relaxation time length	No
OTO determining by DSC (differential scanning calorimetry)	Yes, by OTO (onset temperature of oxidation)	No
Determining of induction time (IT) by DSC method	Yes, by induction time	No
Measuring by cable indenter	Yes, by stiffness ratio	No
IR Fourier spectroscopy of insulation micro-samples	Yes, by characteristic absorption bands	No
Measuring of specific heat of fusion by DSC method for micro-samples of ≥4 mg mass	Yes, for PTFE insulation	No
Thermal gravimetric analysis (TGA)	Yes, by mass loss	No
Frequency dielectric spectroscopy (FDS)	Yes, by dielectric losses in wide frequency range	No
Measuring of recovered (return) voltage in power cables	Yes, by recovered voltage parameters	No
Method of isometric relaxation current measurement (IRC-analysis), i.e. discharge current measurement method	Yes, by relaxation curve parameters	No



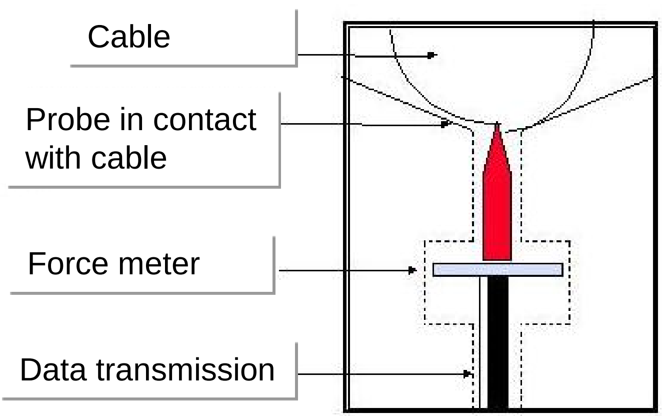


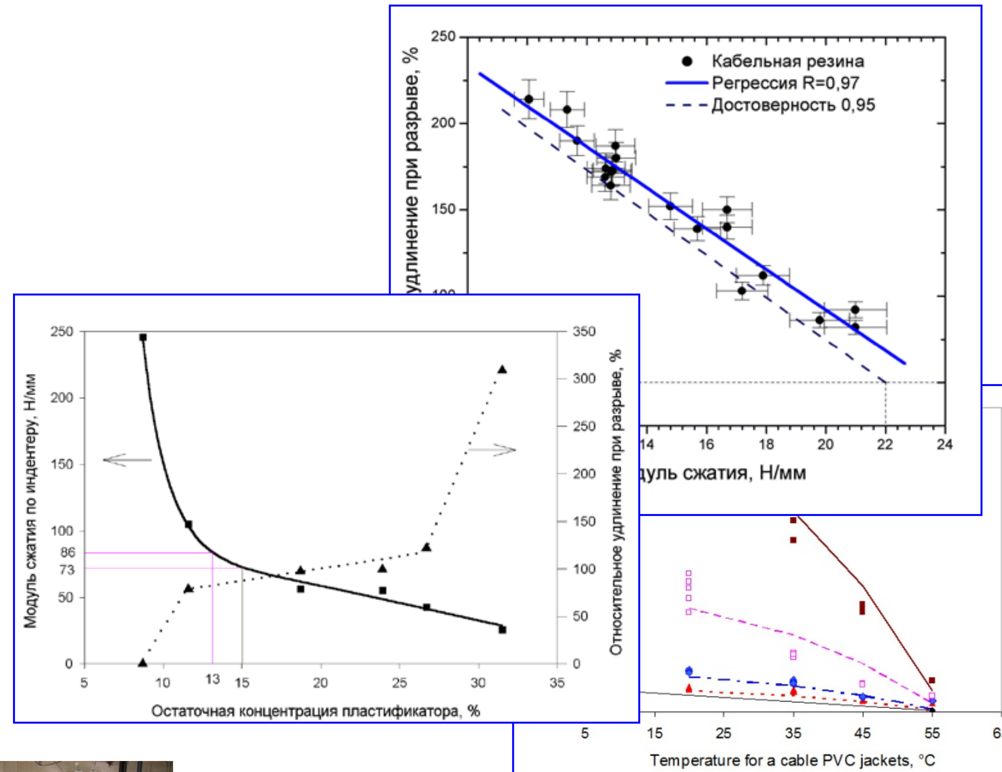



Methods of diagnostics (cont’d)

Method	Condition monitoring and service life determination	Defects localization over the route
Traditional method of partial discharges (PD) recording	Yes, by PD parameters in power cable insulation	No
Method of PD recording at damping oscillating voltage (OWTS-method)	Yes, by PD parameters in power cable insulation	Yes
Reflectometry (time-based, time-based with reference voltage source, wavelet)	Yes, low sensitivity to insulation ageing	Yes
Bridge methods	No	Yes
Topographic methods (induction, capacity, potential methods)	No	Yes, precise positioning
Thermovision monitoring	No	Yes, depending on availability of visual access to route
Frequency reflectometry. Resonance alternating method of standing waves (LIRA - Line Resonance Analysis)	Yes, sensitivity is better than for time-based reflectometry	Yes
Joint (simultaneous) time-and-frequency reflectometry	Yes, sensitivity is better than for time-based reflectometry	Yes

Traditional methods of electrical insulation ageing estimation. Measurement by cable indenter





$$\tau_{\text{service life}} = \tau_{\partial} \cdot \frac{M_{\Pi p} - M(\partial)^{0,95}}{M(\partial)^{0,95} - M_0},$$

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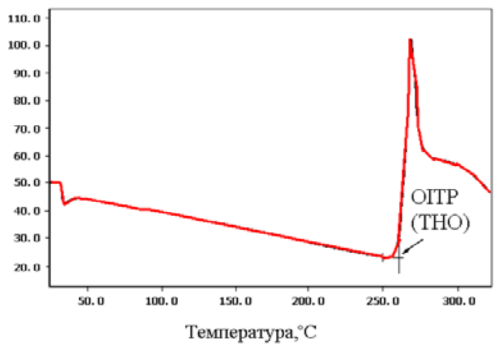
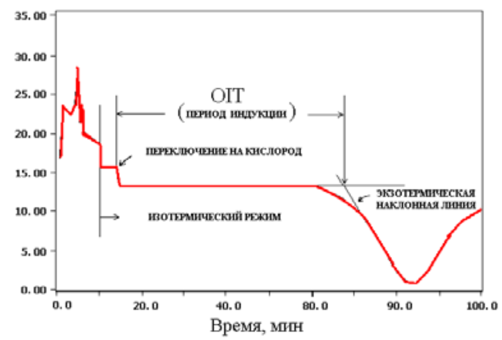
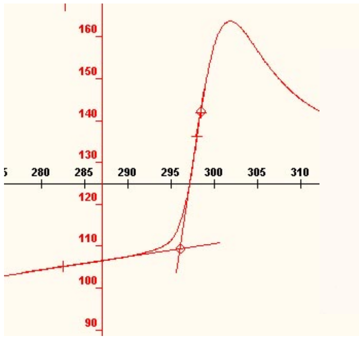
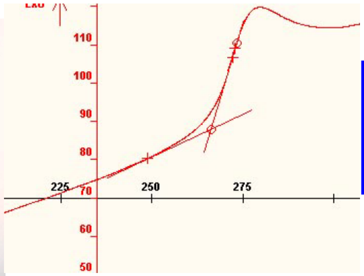
Traditional methods of electrical insulation ageing estimation. Differential scanning calorimetry



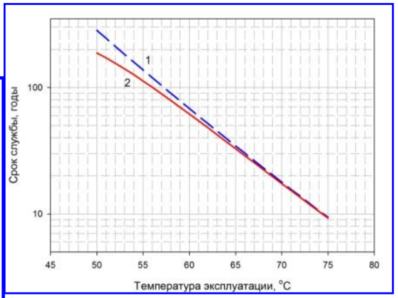






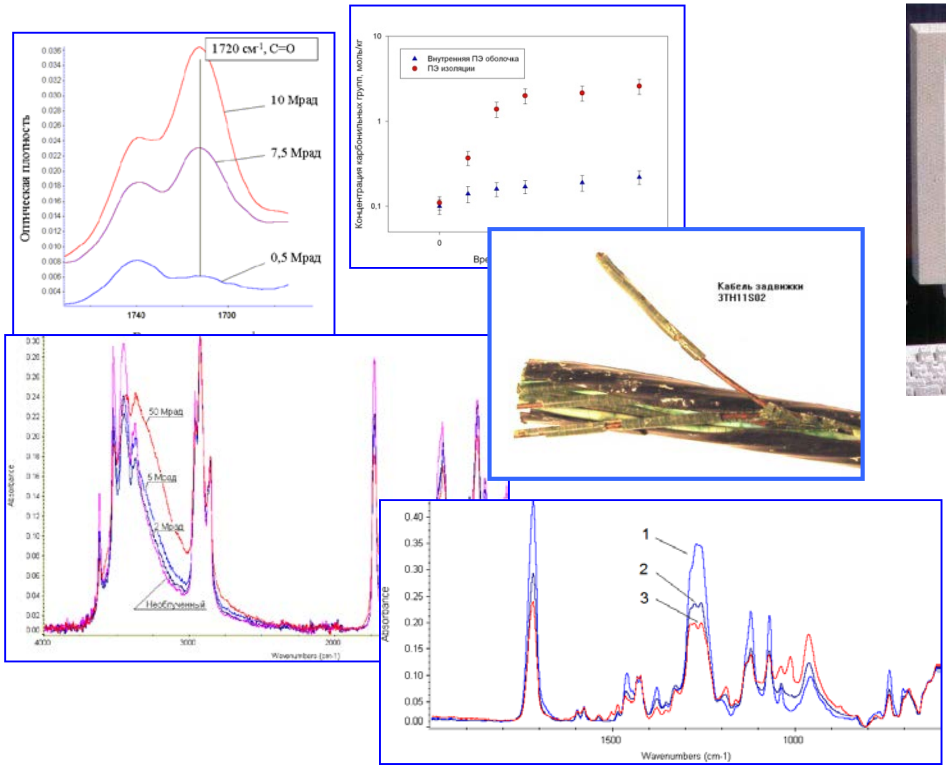
$$\tau_{OITP} = \tau_{test} \cdot \frac{OITP_{test} - OITP_{\lim}}{OITP_{ini} - OITP_{test}} \cdot \frac{OITP_{ini} + 273}{OITP_{\lim} + 273}$$

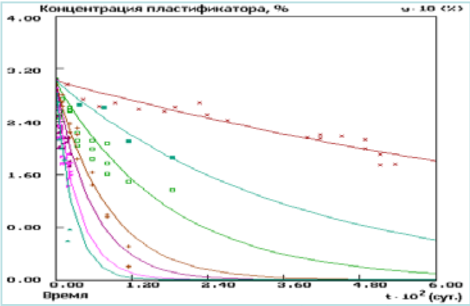
- Polyolefine insulation materials (polyethylene, etc.)
  - Measurement of onset temperature of oxidation (OITP) for micro-samples
  - Measurement of induction time (OIT)



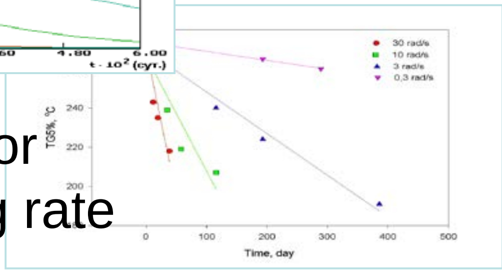
$$\tau(T,\gamma) = a \cdot \exp\left(\frac{E_a}{RT}\right) \cdot \exp(-k \cdot D)$$

Traditional methods of electrical insulation ageing estimation. IR-Fourier spectroscopy





$$C = C_0 \exp[-(k_i^* + k_\gamma P^n)t]$$



IR-Fourier spectroscopy is a traditional method for estimation of polymer insulation materials ageing rate

$$TG5\% = TG5\%(0) \cdot \left(1 - r \cdot P^n \cdot t\right)$$

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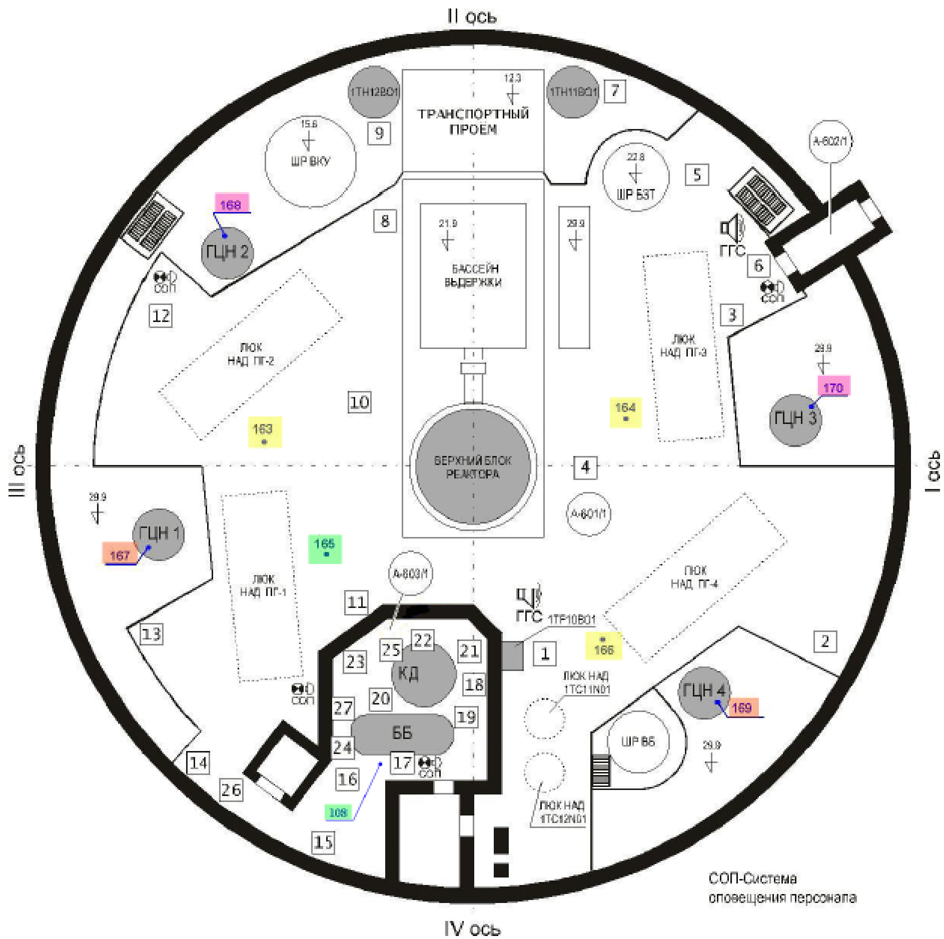
Places of taking microsamples of cable coats and insulation



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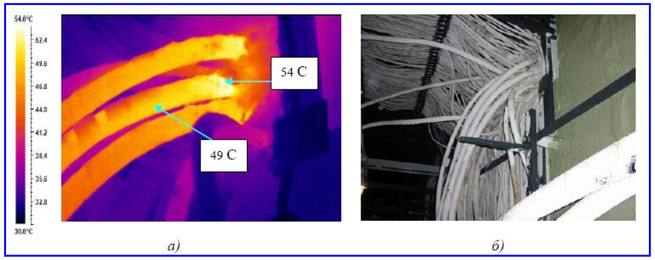
Каналы ЦИИСРК

Отметка 38.1, РО - ГО

MP 1.2.02.0168-2013. “Diagnostics of technical state of power cables with impregnated paper insulation at nuclear plants”

- $R_{ins\ 1\ min\ per\ 1\ km}$, K_a, PI
- Restored voltage
  (LIRV, PIRV)
- OWTS method
- frequency-dielectric spectroscopy
- thermal imaging monitoring



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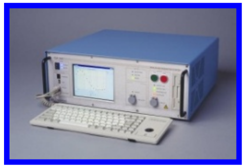

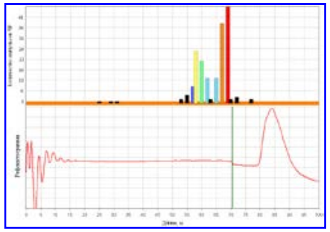

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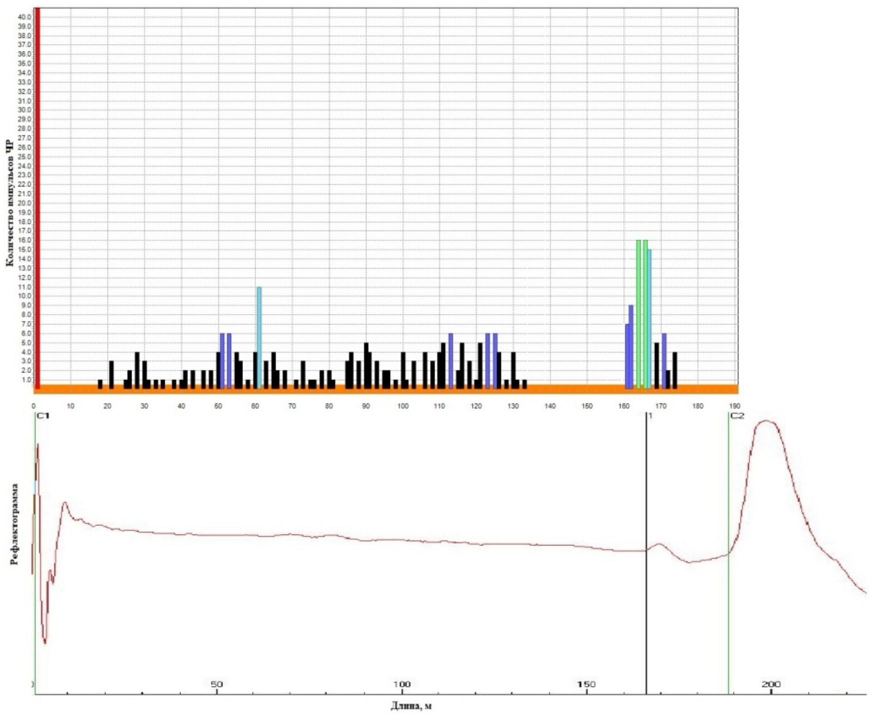
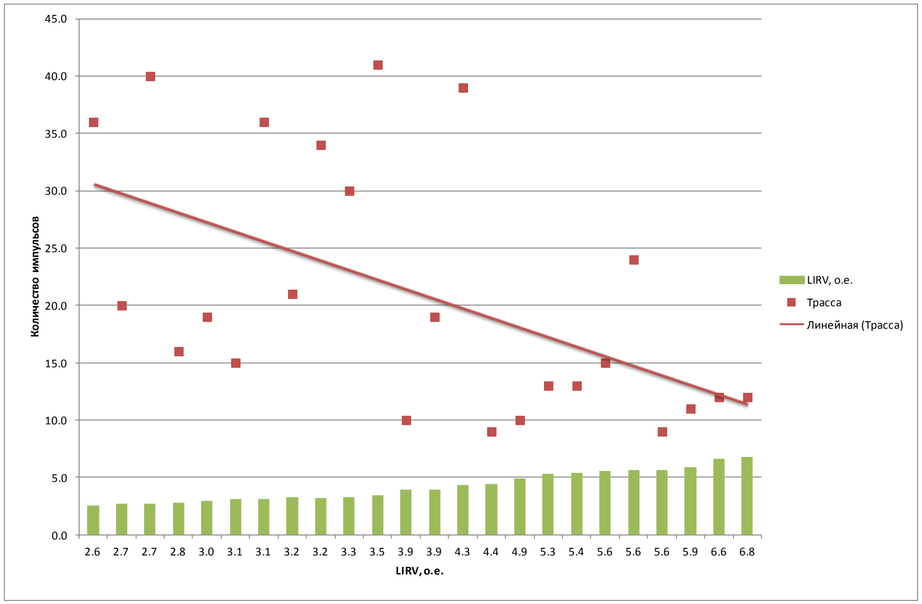
MP 1.2.02.0168-2013. “Diagnostics of technical state of power cables with impregnated paper insulation at nuclear plants”



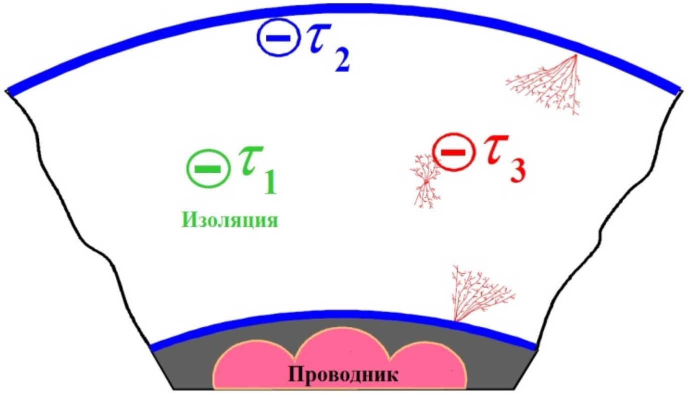
Time reflectometry and PD distribution on a cable line length



PD attenuation because of carbonazation of paper insulation and conduction increasing (especially at cable bend points)

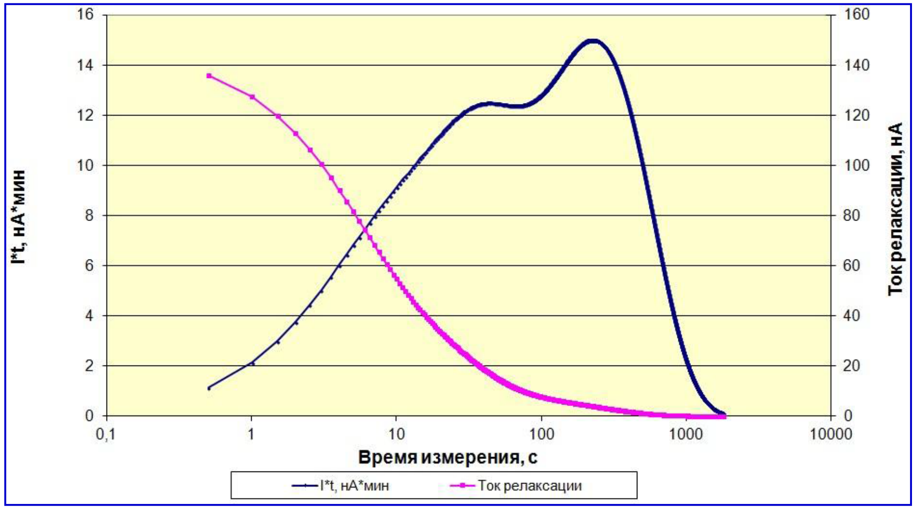
MP 1.2.1.13.1005-2015. “Overall diagnostics of technical state of power cables 6-10 kV with cross-linked polyethylene insulation”

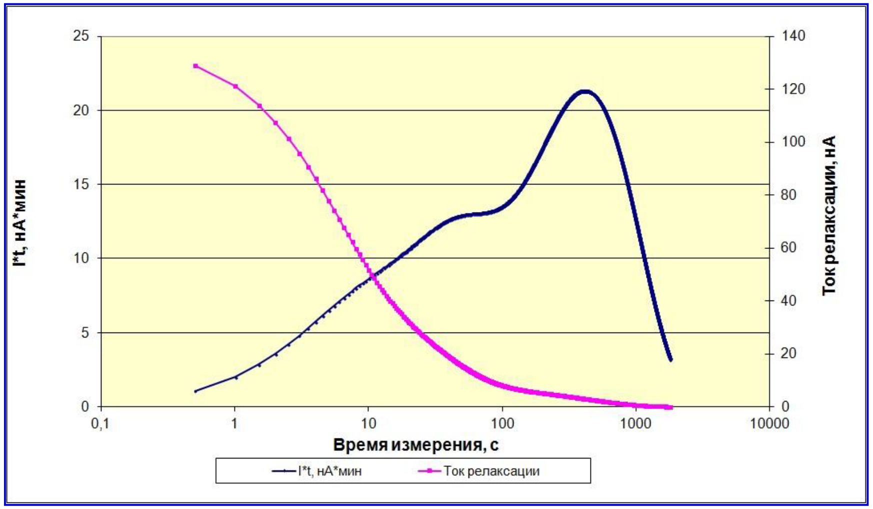
$$I_{relax} = I_0 + \sum_{i=1}^{3} a_i e^{-\frac{t}{\tau_i}}$$

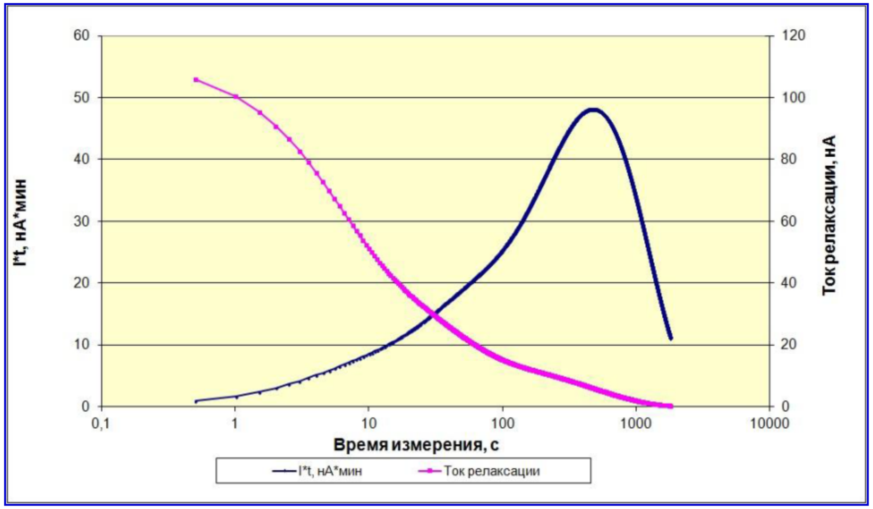


- Insulation ageing
  - insulation ageing diagnostic by measurements of isothermal current of relaxation
- Damages during mounting and couplings installation
  - OWTS-method

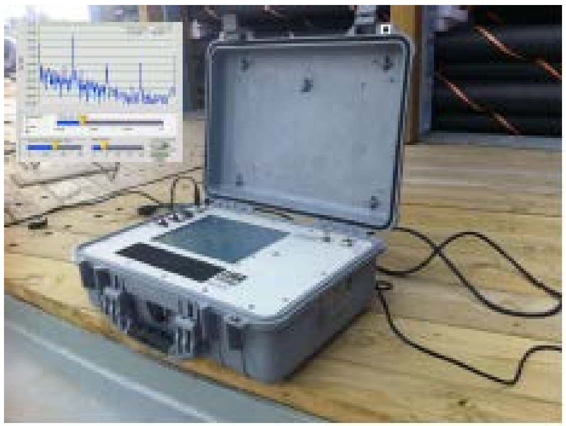
MP 1.2.1.13.1005-2015. “Integrated diagnostics of technical state of power cables 6-10 kV with cross-linked polyethylene insulation”

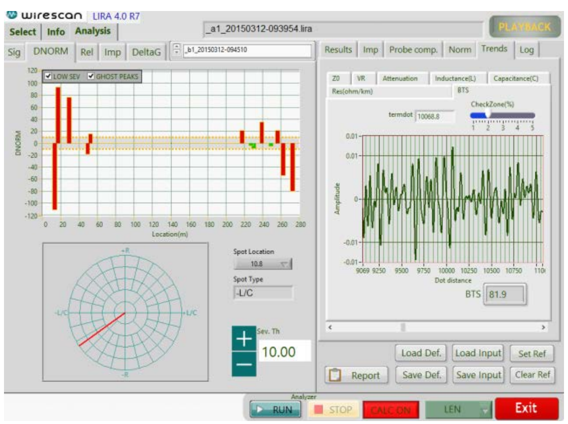






Frequent resonance reflectometry (LIRA method)

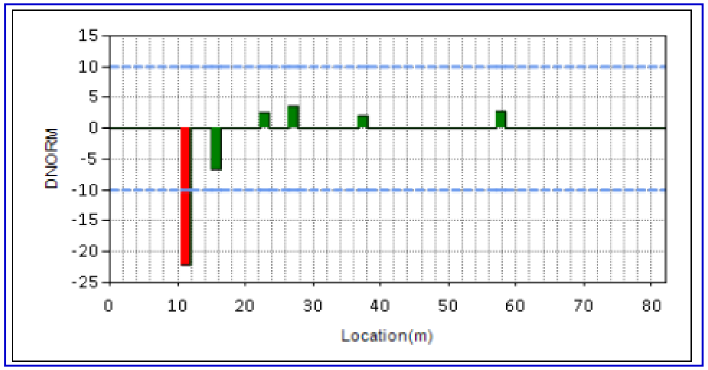


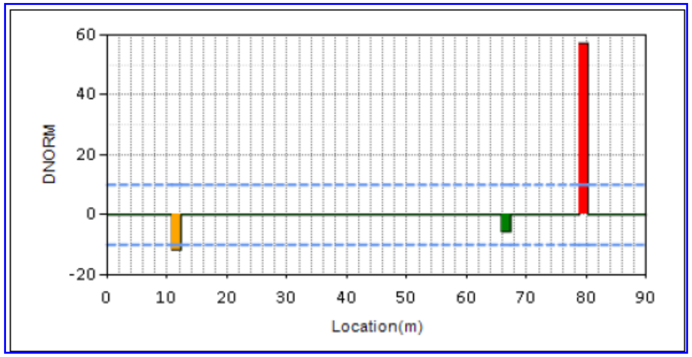


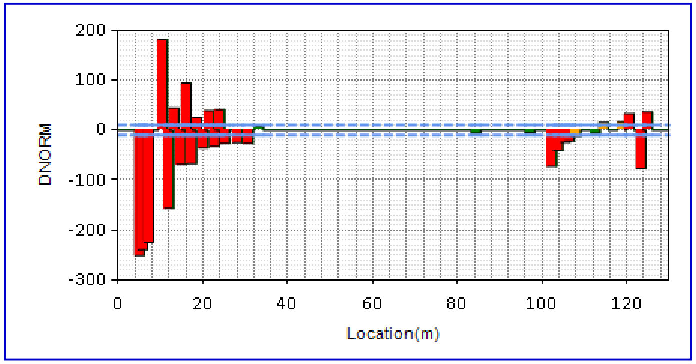
- The method was established under Halden Reactor Project OECD and developed by Wirescan AS
- LIRA (frequency analysis of lines): computer-based frequency resonance reflectometer identifies properties of progressive and ultimate defects in cable lines by characteristics of standing waves generated in the range of 25kHz to 100 MHz with step from 5 kHz to 25 kHz
- Localization of defects in cable lines with accuracy 0,3% of the cable length
- Sensibility to capacitive defects 5 pF/m

Frequent resonance reflectometry (LIRA method)

- Registration of «skinned over» defects in PE insulation of power cables
- Registration of defects in I&C low-voltage cables (cable fault at 400 V)
- It is difficult to interpret a type of defects
- Discontinuities of cable lines give the response that is comparable to the insulation defects
- It is impossible to develop our own diagnostic method since the device is patented

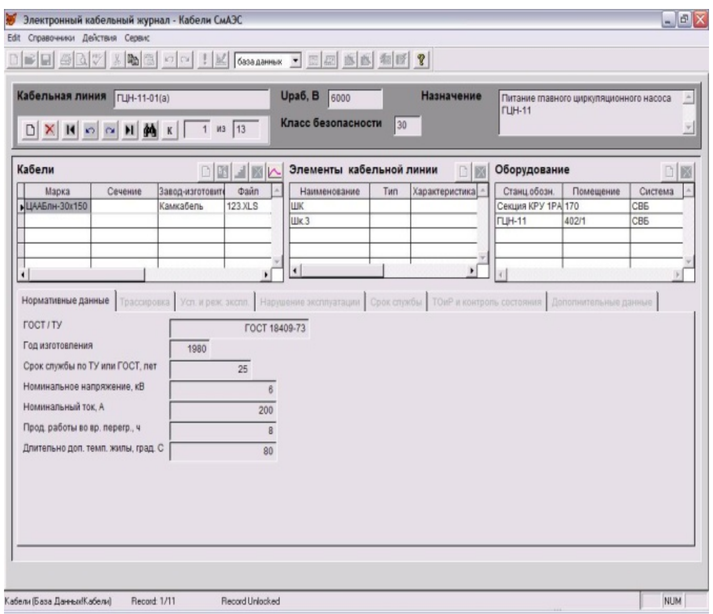


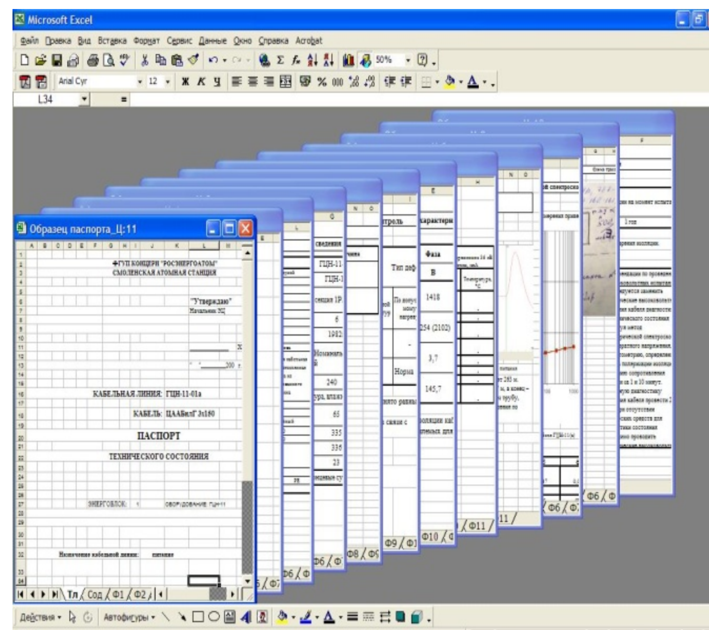




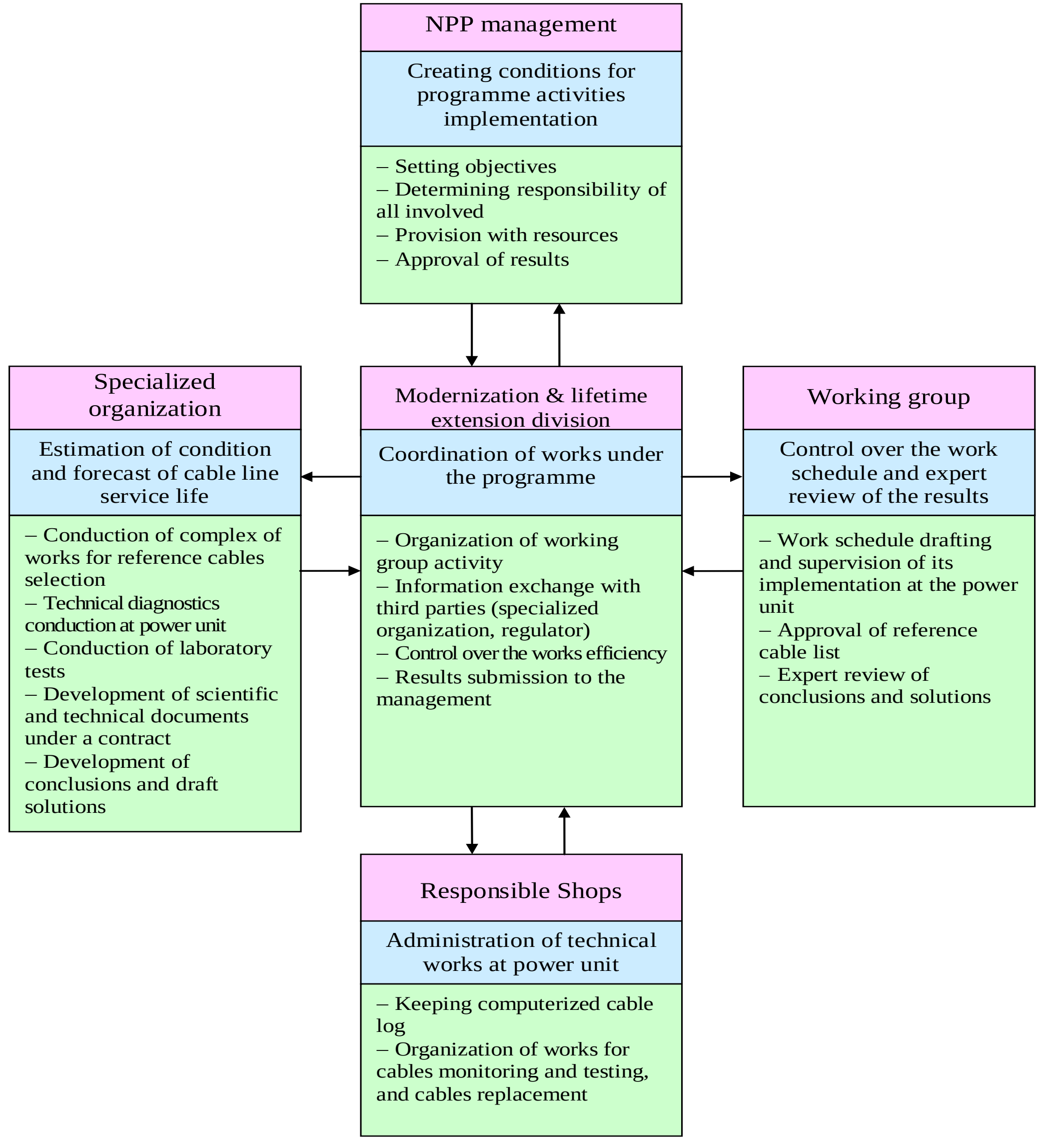
Informational support to technical diagnostics conduction

- Informational support to diagnostics (monitoring) of cables technical condition means a documented certification of the reference cables with computerized cable log keeping, i.e. database for the cables service parameters and residual life characteristics that are to be estimated as part of regular cable inspection





Development and introduction of programmes for the cable residual life management



Standard forms for:

- RLM activities
- Diagnostics procedure

RLM activities and procedure for cables diagnostics

Harsh service condition sections of cable routes, and external influencing factors	List of cable types in “hot spots”	Methods of diagnostics (monitoring) of technical condition	Technical documents regulating diagnostics (monitoring) of condition	Measures to reduce EIF impacts on ageing rate	References to documents	Terms of completion (regularity of action)	Responsible persons	Remarks

Reference cable in “hot spot” with its identificator or local point of micro-sampling and measurements	Type of insulation/internal layer/outer jacket	Mechanisms of cable insulation materials ageing	Prevailing mechanism of material ageing	Determining indicators of component material condition	Criteria for insulation material condition assessment	Actual values of determining indicators of cable insulation materials condition by monitoring results	Recommended additional monitoring of technical condition	Terms of completion	Responsible persons	Reference to document regulating diagnostics (monitoring) conduction

ПО1.2.1.02.999.0184-2013

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Thank you for your attention!