

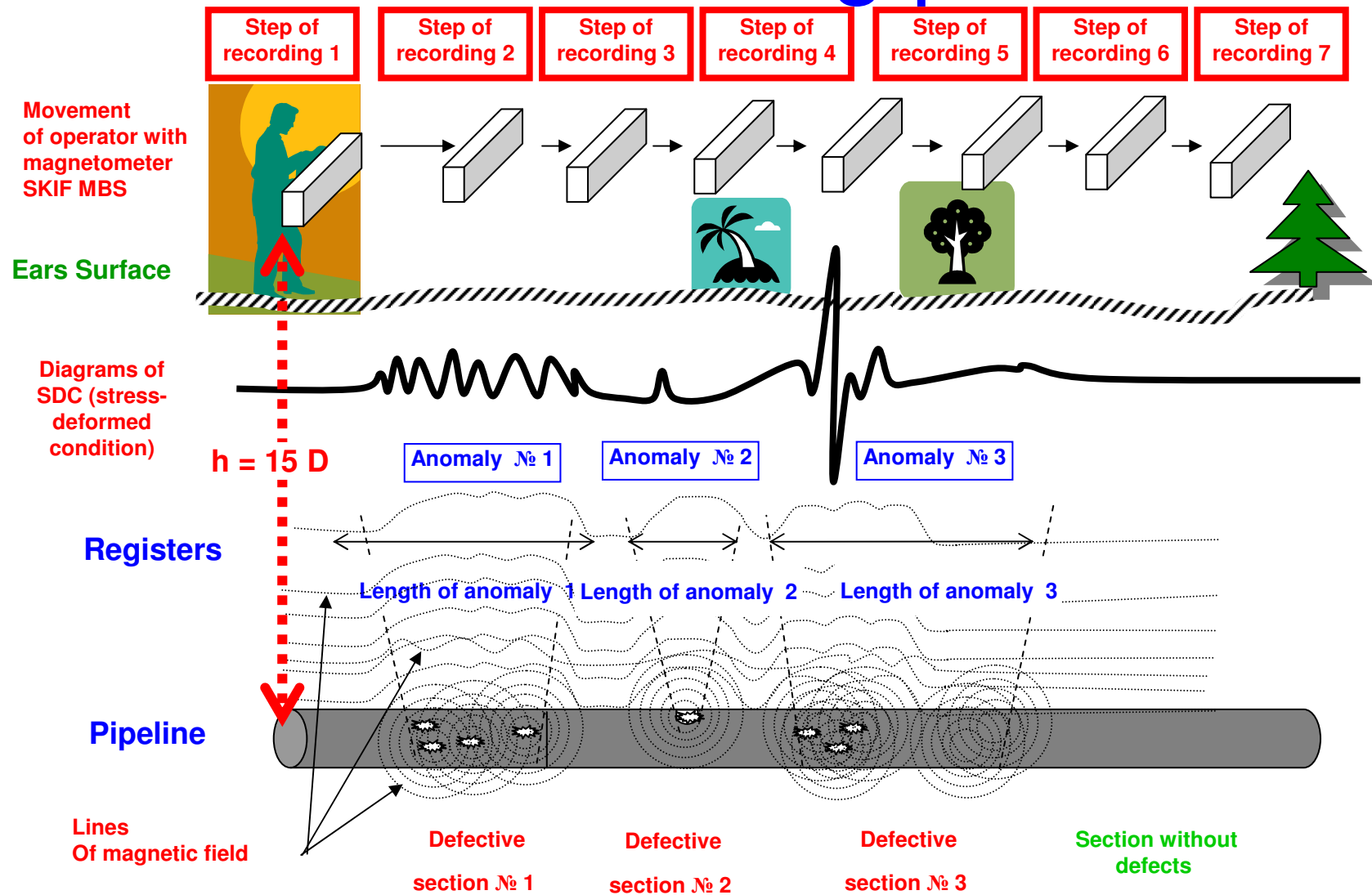


OOO R&D CENTRE "TRANSKOR-K", RUSSIA

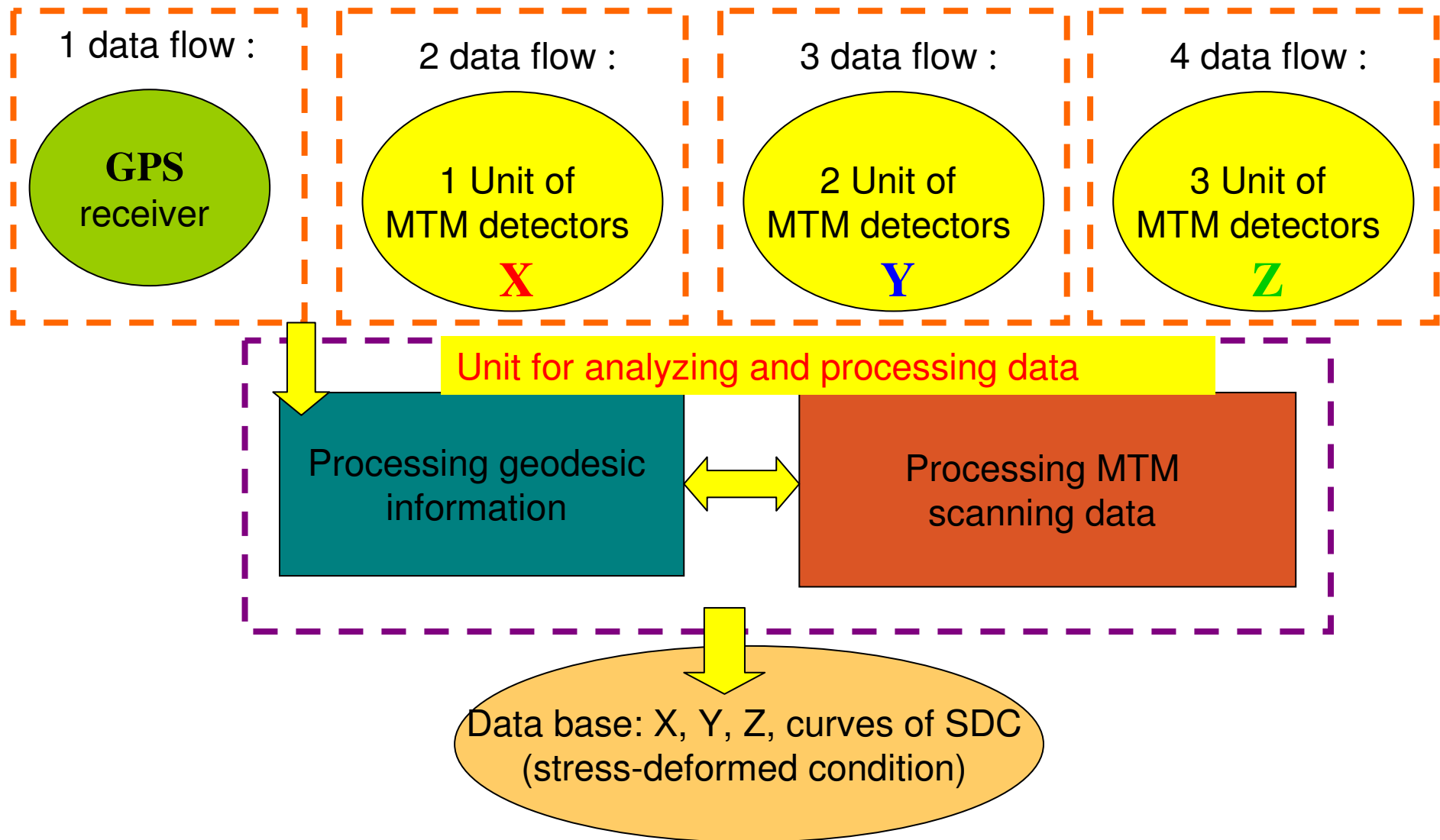
Magnetic Tomography method for inspecting pipelines (MTM)



MTM scanning process



Scheme of complex processing MTM data of underground (sub-water) object

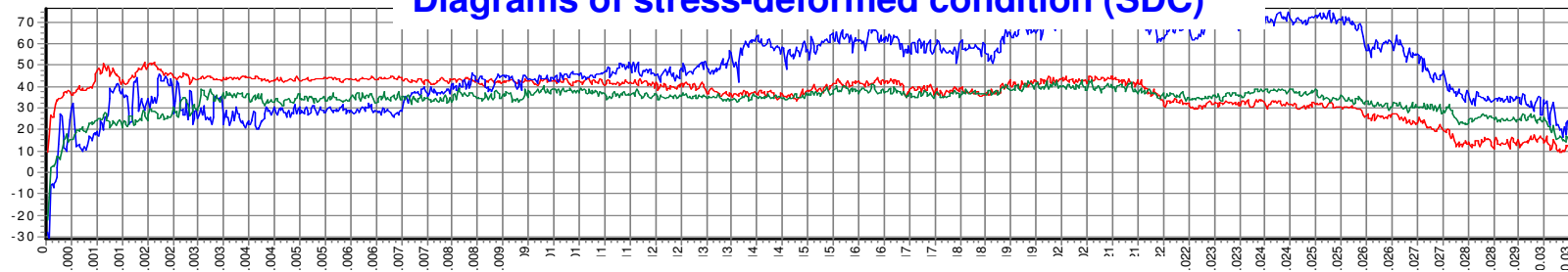


SDC diagrams

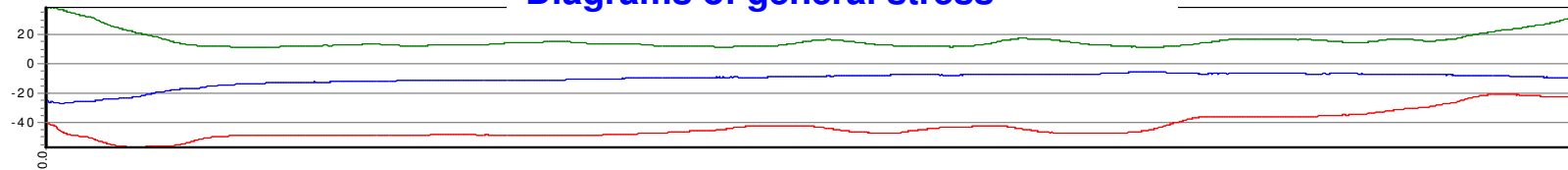
05.04.2006

Object name, direction of inspection – according a product flow

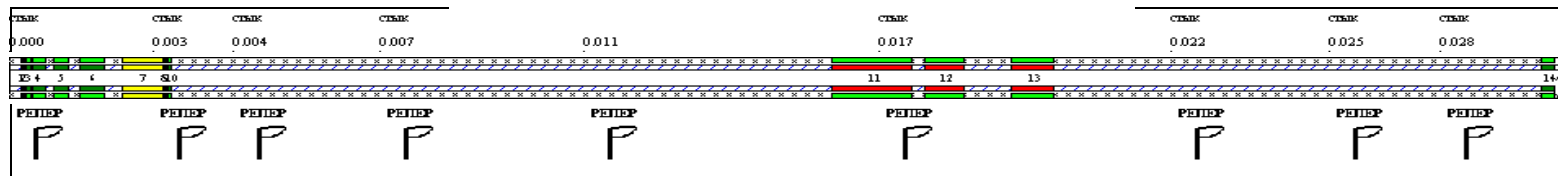
Diagrams of stress-deformed condition (SDC)



Diagrams of general stress

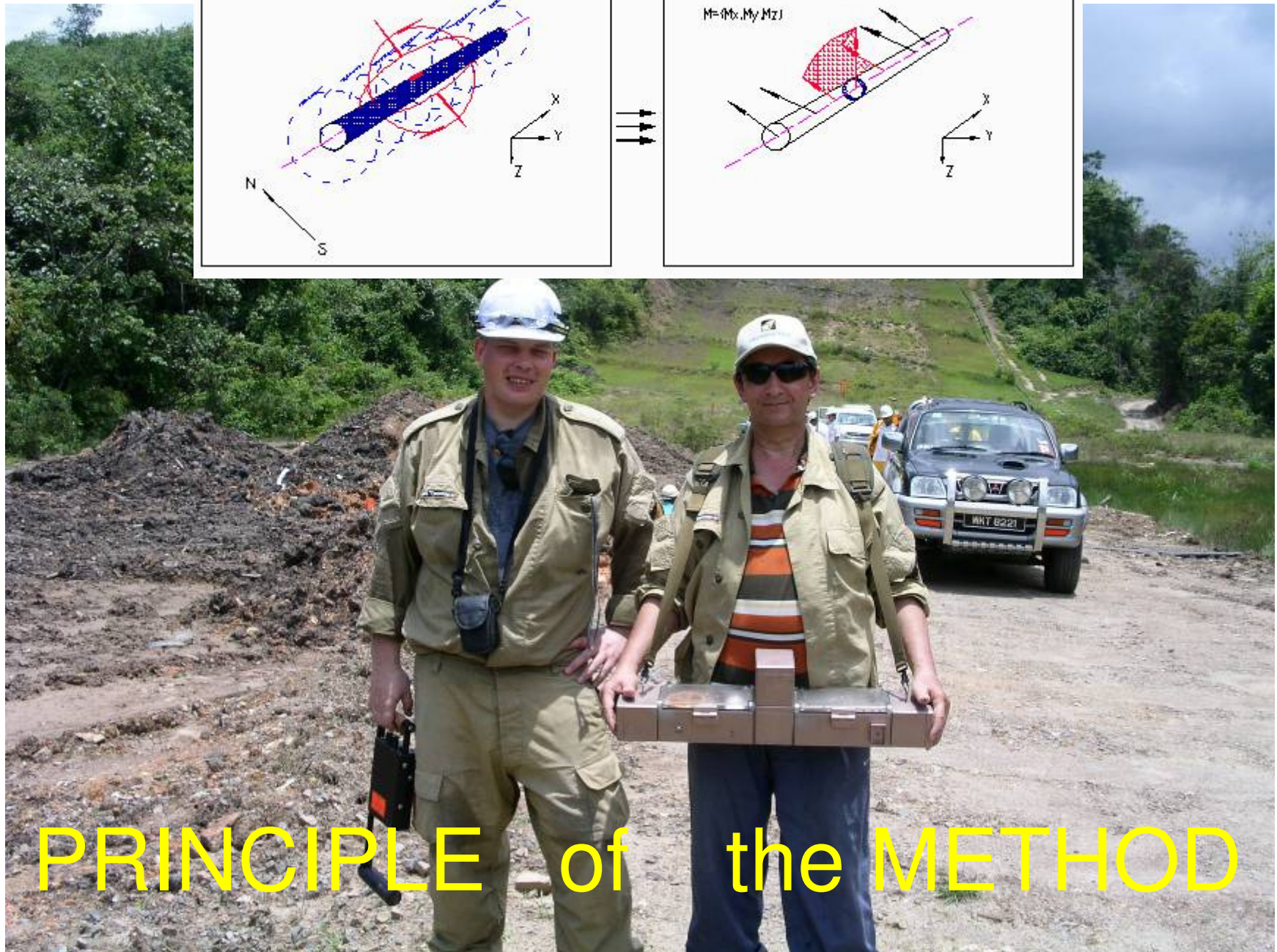
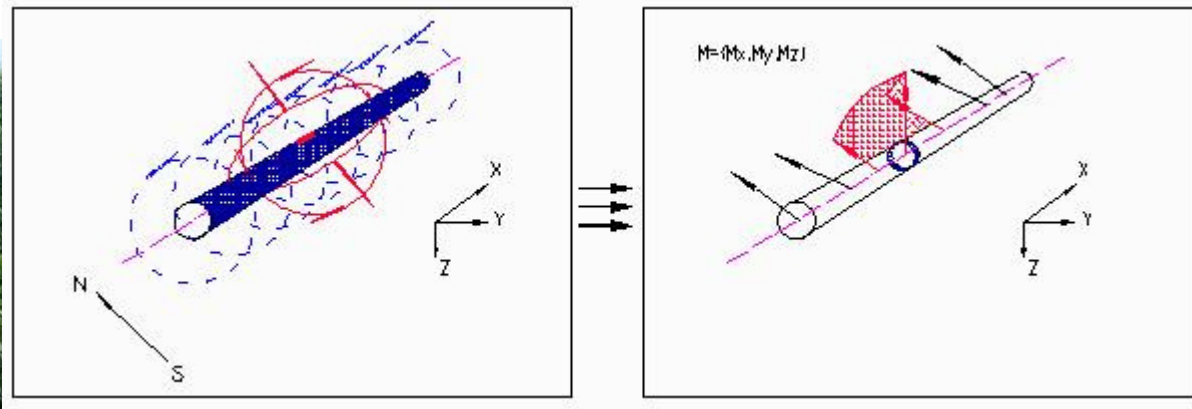


Pipeline situation scheme



MTM data field registration



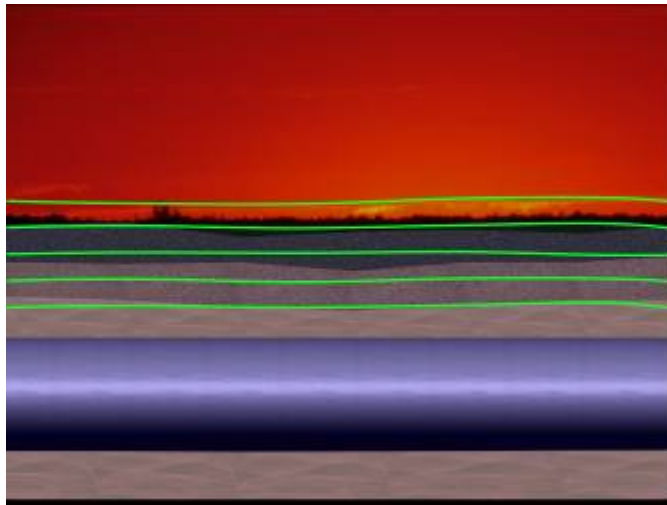


PRINCIPLE of the METHOD

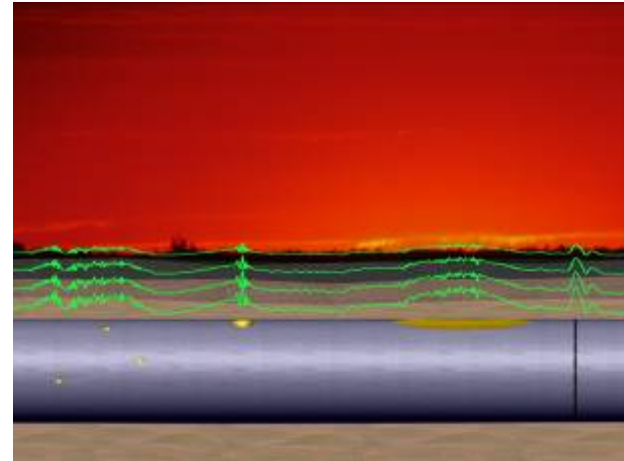
Non-destructive testing works (NDT) in a pit



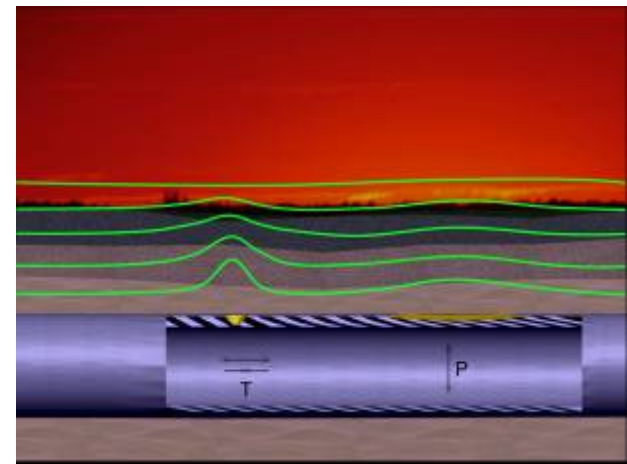
MTM data office processing



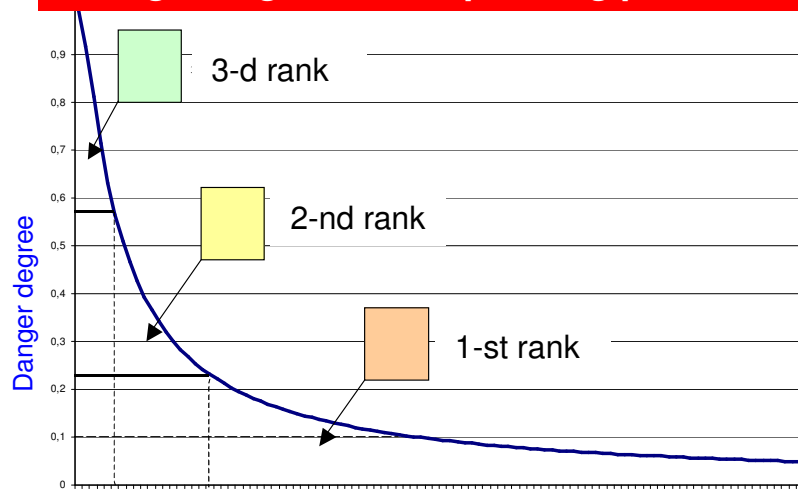
Section without SDC (stress-deformed condition) anomalies



Sections with anomalies



Diagrams of distribution of anomaly danger degree/ safe operating pressure



Parameter of calculation – free accident operation term, years

Ranks of anomalies danger

3

2

1

CATEGORY OF METAL CONDITION

Good

Admissible

Inadmissible

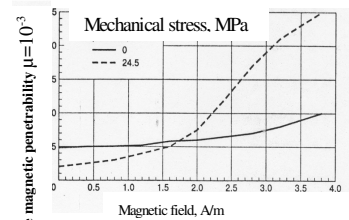
RECOMMENDATION ON ENHANCING RELIABILITY

Monitoring
without repair

Scheduled
repair

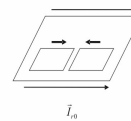
First priority
repair

Physical grounds of the method enabling the development of the magnetic tomography method



$$\Delta = \frac{\delta I_{rs}}{\Delta \sigma} = \frac{k \lambda_{100} (1 - N_2) I_{rs}}{\frac{1}{8} \mu_0 N_1^2 I_s^2}$$

Magnetoelastic hysteresis phenomenon



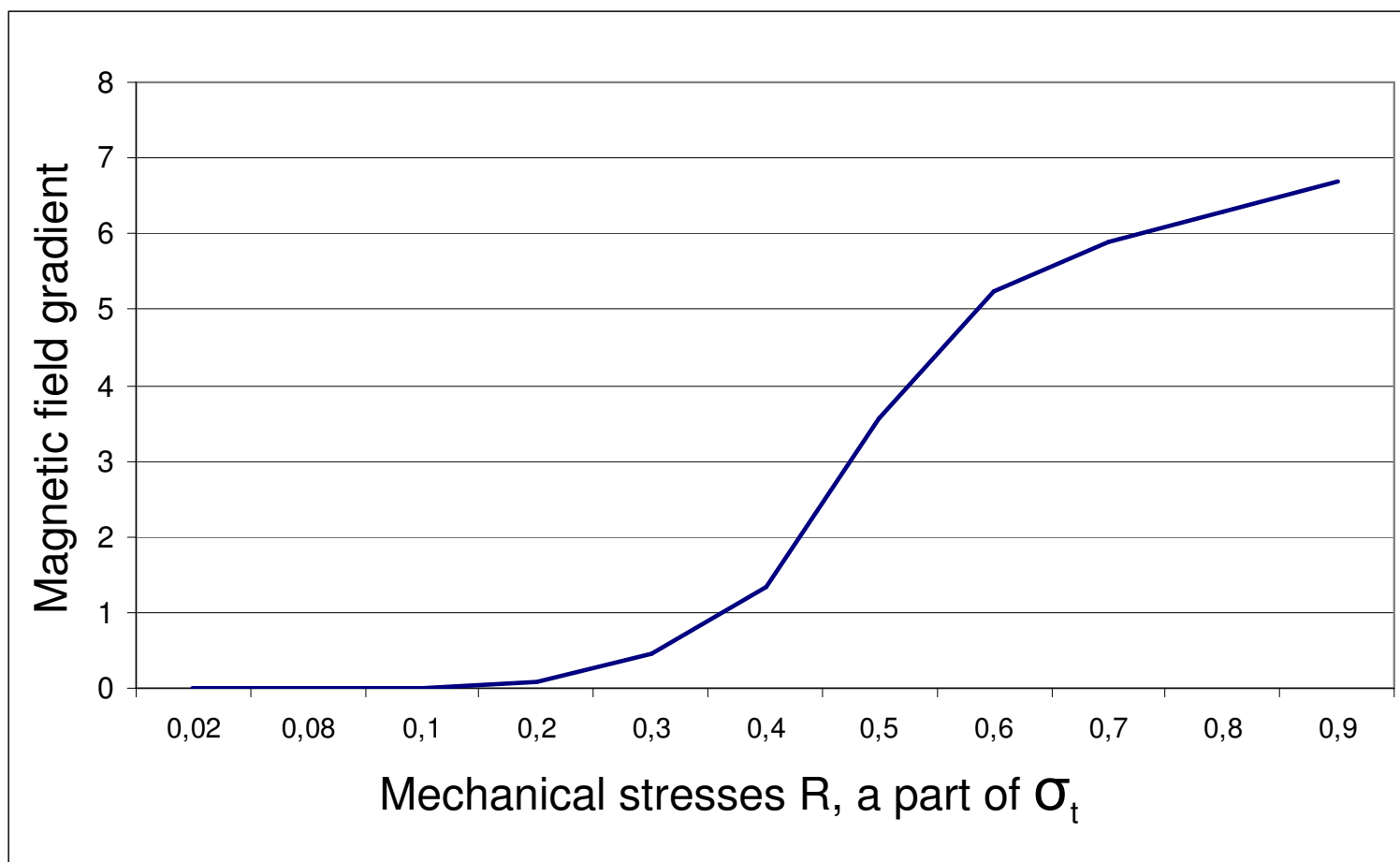
$$\begin{aligned} \frac{1}{2}(1+v)k\lambda_{100}\Delta\sigma &= \frac{1}{2}(1+v)\left(\frac{1}{2}\mu_0 N_1 I_s \Delta I^+ + \mu_0 H_c \Delta I^+ - \mu_0 H_c \Delta I^-\right) \\ \frac{1}{2}(1-v)k\lambda_{100}\Delta\sigma &= \frac{1}{2}(1-v)\left(\frac{1}{2}\mu_0 N_1 I_s \Delta I^- + \mu_0 H_c \Delta I^- + \mu_0 H_c \Delta I^+\right) \end{aligned}$$

- $\frac{1}{2}(1+v)\frac{1}{2}(1-v)$ Part of volume with magnetization oriented lengthwise vector I_{s0} and towards it, correspondingly;

- $v = \frac{I_{rs}}{I_s}$ Residual magnetization of magnet in adjusted condition, that is, after multi-repeated imposition of stress;

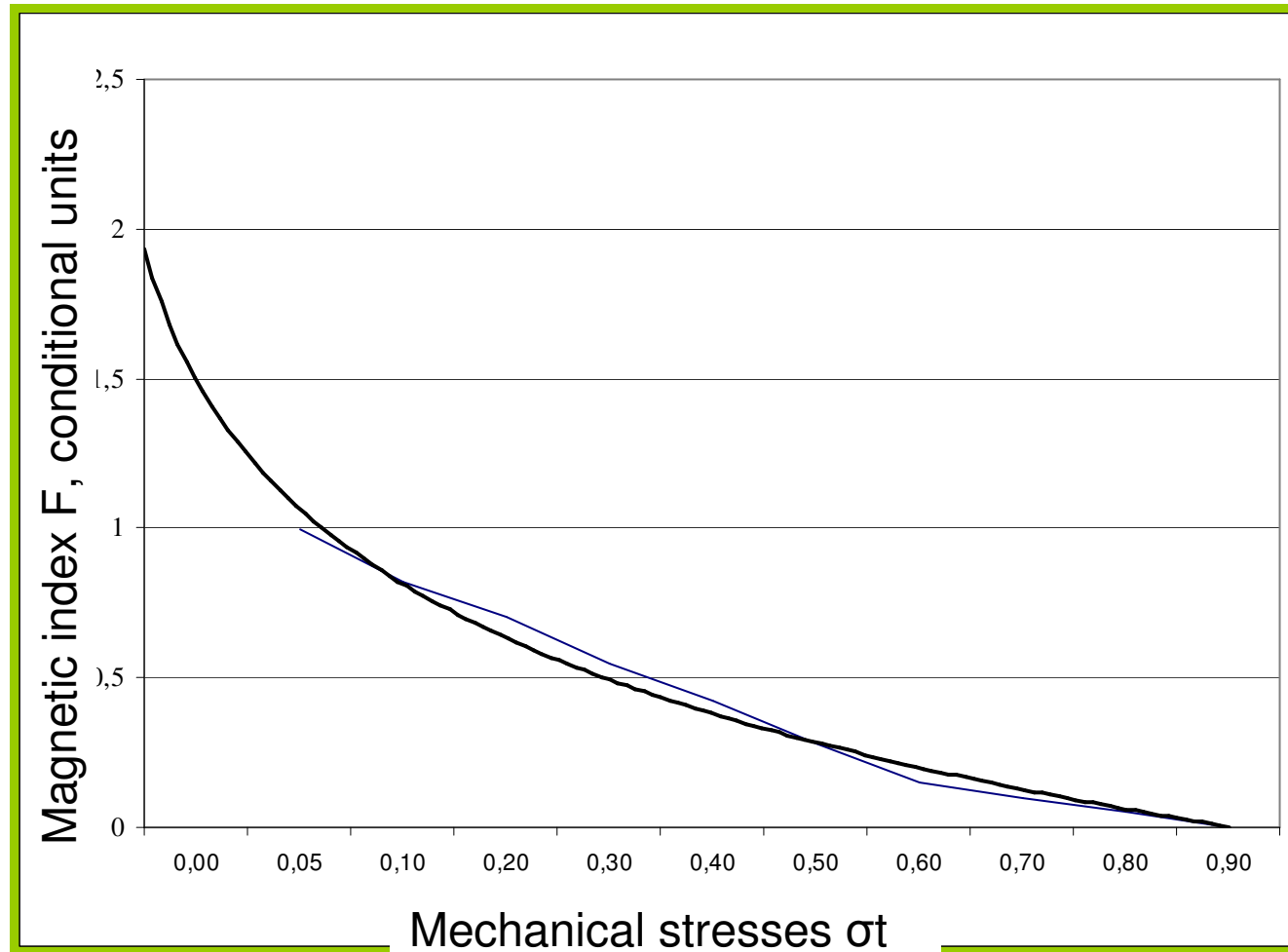
- I_s – Magnetization of saturation;
- $k\lambda_{100}\Delta\sigma$ – Change of magnetoelastic energy when stress is imposed tension σ ;
- λ_{100} – Constant of magnetostriction;
- $k - c$ – Average angular coefficient;
- $\mu_0 N_1 I_s \Delta I^+$ – Change of domains magnetostatic energy;
- $\mu_0 = 4\pi 10^{-7}$ H/m
- N_1 – Demagnetizing index of inclusions (various types of defects of structure);
- $\Delta I^+, \Delta I^-$ – Complete piezomagnetic change of magnetization in the first and second volumes, correspondingly;
- $\mu_0 H_c \Delta I^-$ – Energy of interaction of magnetization with field, essential for interdomain boundaries to get over potential barriers, H_c – average critical field;
- $\mu_0 H_s \Delta I^-$ – Is developed owing to detention of domains at energy barriers (defects of array) and also owing to additional magnetization of matrix by inclusions having value of residual magnetization higher than matrix's.

Calculation of serviceability parameters



Dependence between a pipeline magnetic field density and mechanical stresses

$$F = -0,6245 \ln(\sigma) + 1,5$$



Dependence between complex magnetic index F and mechanical stresses in a pipeline

Magnetic field density in H or Am ⁻¹	10 ⁻⁹
Range of an object wall thickness	Starting with 2.8 mm
Limits regarding pipelines diameters D	$56 \leq D \leq 1420$ mm и $D >$
Rate of MTM-inspection	2-5 m/s
Maximum pressure	Not limited
Minimum pressure for gas pipelines	0,02 MPa
Minimum radius of turning (bend)	Not limited
Internal minimum diameter	Not limited
Dimensions	200×200×750 mm
Weight of the tool	4,7 kg
Length of an inspected section, minimum	40 m
Volume of registration along lengthways an object	100 %
Admissible deviation from the axis of an underground object	Not more than 3 D
Admissible distance between the magnetometer and a pipeline (deviation from axis, depth of bedding)	20 D
Step of scanning (registration and data recording by detectors), maximum	0,25 m
Error in determining longitudinal coordinate of anomaly	± 1,5 m
Error in determining angular coordinate of anomaly	20°

MTM Report

Таблица 3.1

Register of revealed MTM anomalies

Информация по местам выявления					Информация по параметрам							Расстояние от предыдущей привязки, м	Расстояние до следующей привязки, м	Вид предполагаемой аномалии	Максимальное безопасное давление, МПа	Период безопасной работы при РБса, лет
Координаты привязки, м	Вид привязки	Примечание	GPS-координаты		№ аномалии	Состояние металла	Интегральный показатель F	Часовое расхождение аномалии	Начало аномалии, м	Конец аномалии, м	Длина аномалии, м					
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
0	Общая	участок КПП справа	E57°25'01.13"	N60°04'47.79"	1	3	0.87925	8 ч 46 мин	43.20	47.00	4.80	43.00	-159.80	Потери металла (**)	0.50	16.4
			E57°25'00.99"	N60°04'47.64"	2	3	0.96665		182.80	184.00	1.20	182.80	-22.95		0.50	18.4
			E57°25'05.57"	N60°04'46.54"	3	3	0.95371		194.80	196.00	1.20	194.80	-21.85		0.50	18.4
			E57°25'08.56"	N60°04'46.02"	4	3			187.80	189.00	1.20	187.80	-16.82		0.50	18.4
			E57°25'08.54"	N60°04'46.00"	5	3			187.80	189.00	1.20	187.80	-16.82		0.50	18.4
			E57°25'05.11"	N60°04'46.19"	6	3			187.80	189.00	1.20	187.80	-16.82		0.50	18.4
		аномалия ГРП от 10.5м от начала ГРП.061	E57°25'05.09"	N60°04'46.15"	7	3			187.80	189.00	1.20	187.80	-16.82		0.50	18.4
			E57°25'05.09"	N60°04'45.90"	8	3			187.80	189.00	1.20	187.80	-16.82		0.50	18.4
			E57°25'05.09"	N60°04'45.52"	9	3			187.80	189.00	1.20	187.80	-16.82		0.50	18.4
			E57°25'05.09"	N60°04'45.37"	10	3			187.80	189.00	1.20	187.80	-16.82		0.50	18.4
			E57°25'05.09"	N60°04'45.14"	11	3	0.87076		187.80	189.00	1.20	187.80	-16.82		0.50	18.4
445			E57°25'05.34"	N60°04'45.11"	12	3	0.87076	8 ч 11 мин	187.80	189.00	1.20	187.80	-16.82		0.50	18.4
466			E57°25'05.34"	N60°04'45.11"	13	3	0.87076		187.80	189.00	1.20	187.80	-16.82		0.50	18.4
473			E57°25'05.34"	N60°04'45.11"	14	3	0.87076		187.80	189.00	1.20	187.80	-16.82		0.50	18.4
476			E57°25'05.34"	N60°04'45.11"	15	3	0.87076		187.80	189.00	1.20	187.80	-16.82		0.50	18.4
485			E57°25'05.34"	N60°04'45.11"	16	3	0.87076		187.80	189.00	1.20	187.80	-16.82		0.50	18.4
553			E57°25'05.34"	N60°04'45.11"	17	3	0.87076		187.80	189.00	1.20	187.80	-16.82		0.50	18.4
703	Общая	аномалия на 50.0м	E57°25'05.34"	N60°04'45.11"	18	3	0.87076		187.80	189.00	1.20	187.80	-16.82		0.50	18.4

Coordinates of anomaly, m

Type of fixation

GPS-coordinates: latitude, longitude

Metal condition: good (3); admissible (2); inadmissible (1)

№ anomaly

Integral index F, conditional units

Beginning, end, Length of anomaly

Angular coordinate of anomaly, hour

Distance from the preceding fixation (-) to the next fixation (+)

Prognosis of anomaly type

Safe operating pressure, MPa, Tsaf

Free accident operation term, years, at Tsaf

Rank of anomaly

Notes:

Recommendation on enhancing reliability of a pipeline section

- Section for the first priority repair (1)
- Section for the scheduled repair (2)
- Section without repair - monitoring (3)

Types of anomalies:

- Metal loss
- Crack-like defects
- Geometry change
- Weld joint defects
- SDC (stress-deformed condition) anomalies

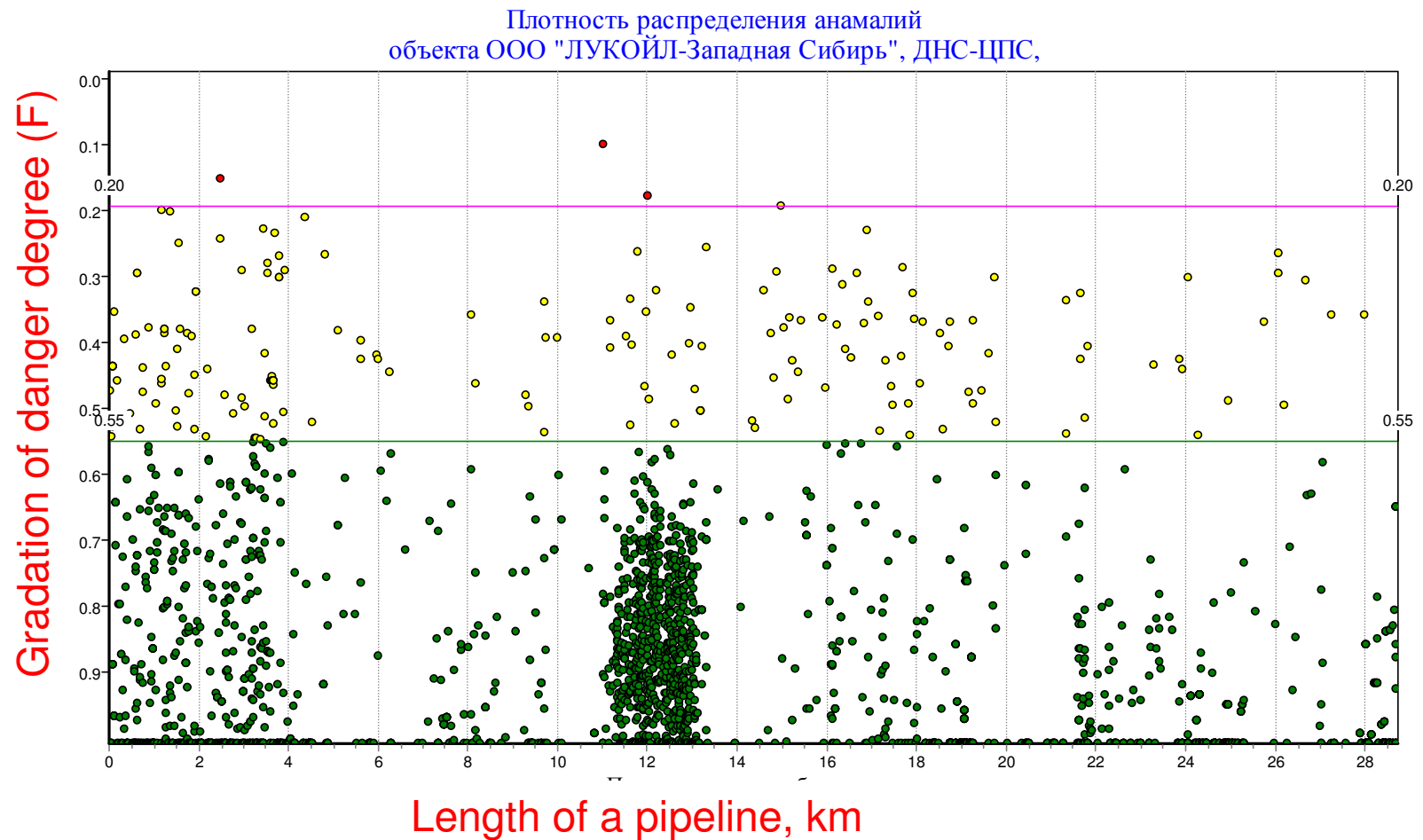




RDC "Transkor-K". Moscow 2006

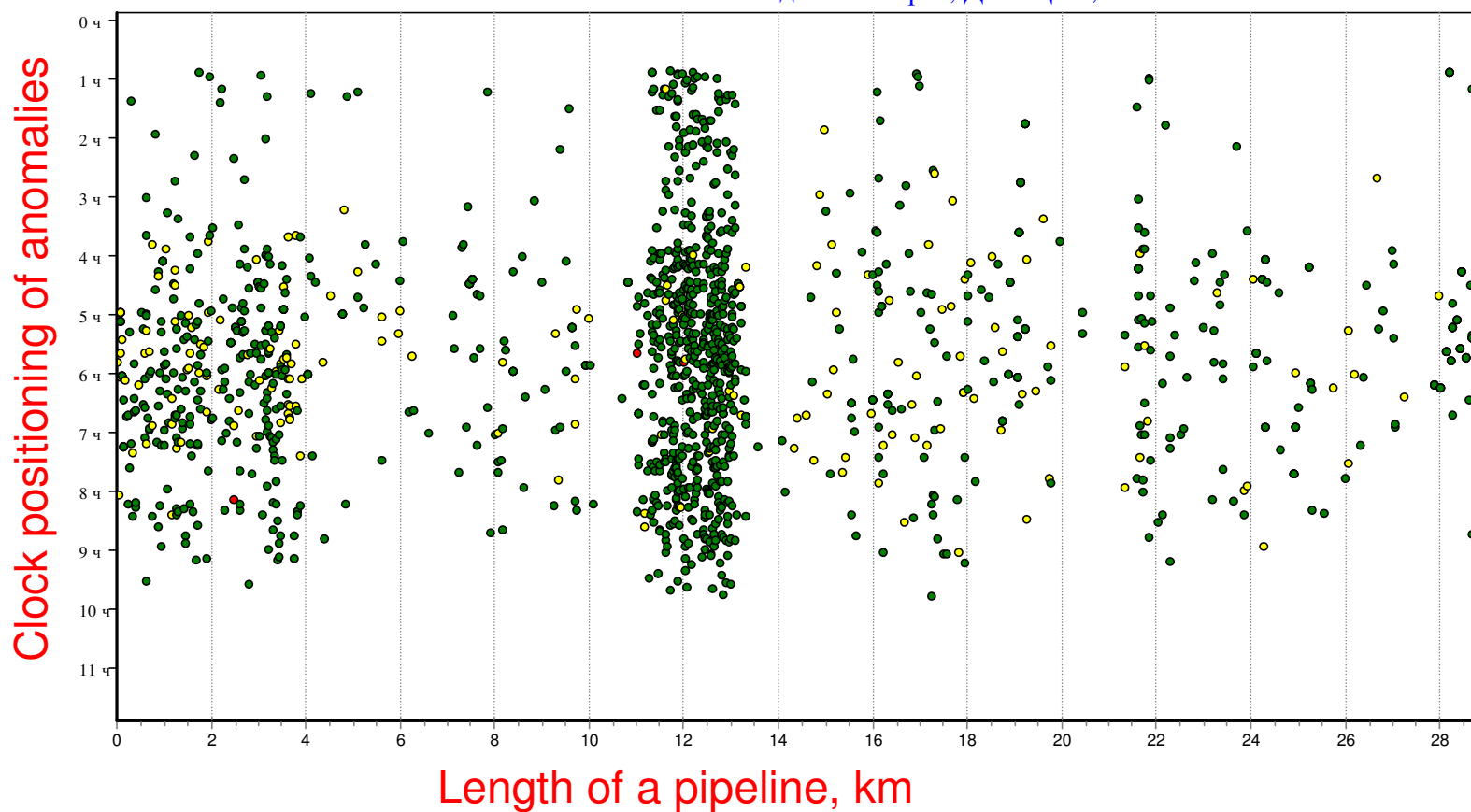
Map-scheme
with fixing an object
to topo-base
(Tierra Del Fugo,
Patagonia, Argentina)

Distribution of anomalies lengthways an object



Distribution of angular coordinates of anomalies

Часовое расположение аномалии
объекта ООО "ЛУКОЙЛ-Западная Сибирь", ДНС-ЦПС,



The following is included into the text:

Register

Tables

Photos

1. Situational, geodesic and other schemes, tables describing the MTM results;
2. Data illustrating the methodic of field and office works;
3. Data characterizing principals and peculiarities of revealing SDC anomalies of a ferro-magnetic pipeline;
4. Data relevant to the work results.

The following is included as graphic attachments:

Maps

Diagrams

Schemes

1. Maps of distributing parameters of SDC anomalies of an object;
2. Situational Maps-schemes of an object; diagrams
3. Maps of geodesic positioning of an object by GPS-coordinates;
4. Schemes of comparing the inspection data with topo-base of a pipeline route.



Typical structure of data submitted during any Report term