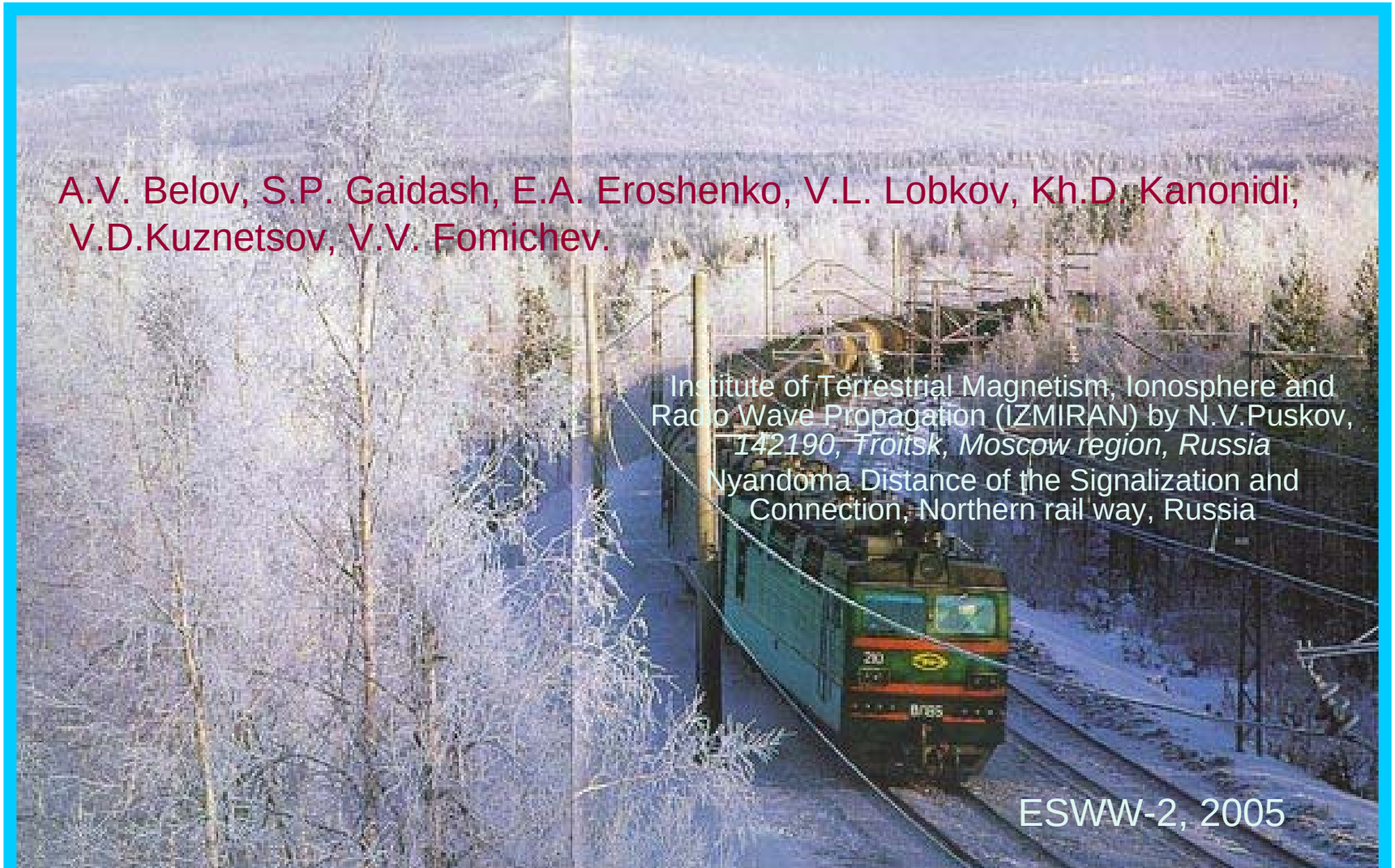
INFLUENCE OF THE GREAT GEOMAGNETIC DISTURBANCES ON THE NORTHERH RAILWAYS OPERATING



A.V. Belov, S.P. Gaidash, E.A. Eroshenko, V.L. Lobkov, Kh.D. Kanonidi, V.D.Kuznetsov, V.V. Fomichev.

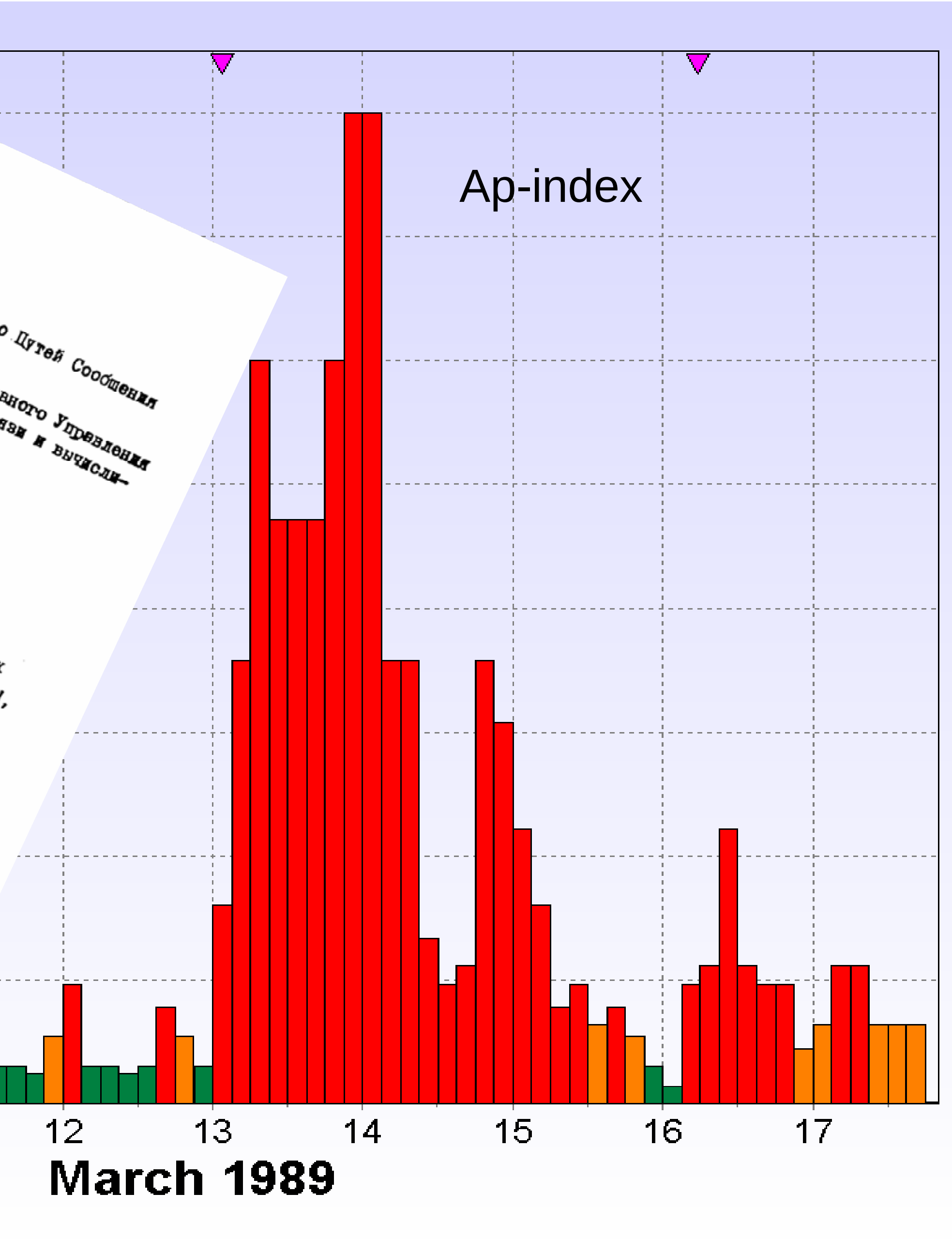
Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation (IZMIRAN) by N.V.Puskov, *142190, Troitsk, Moscow region, Russia*

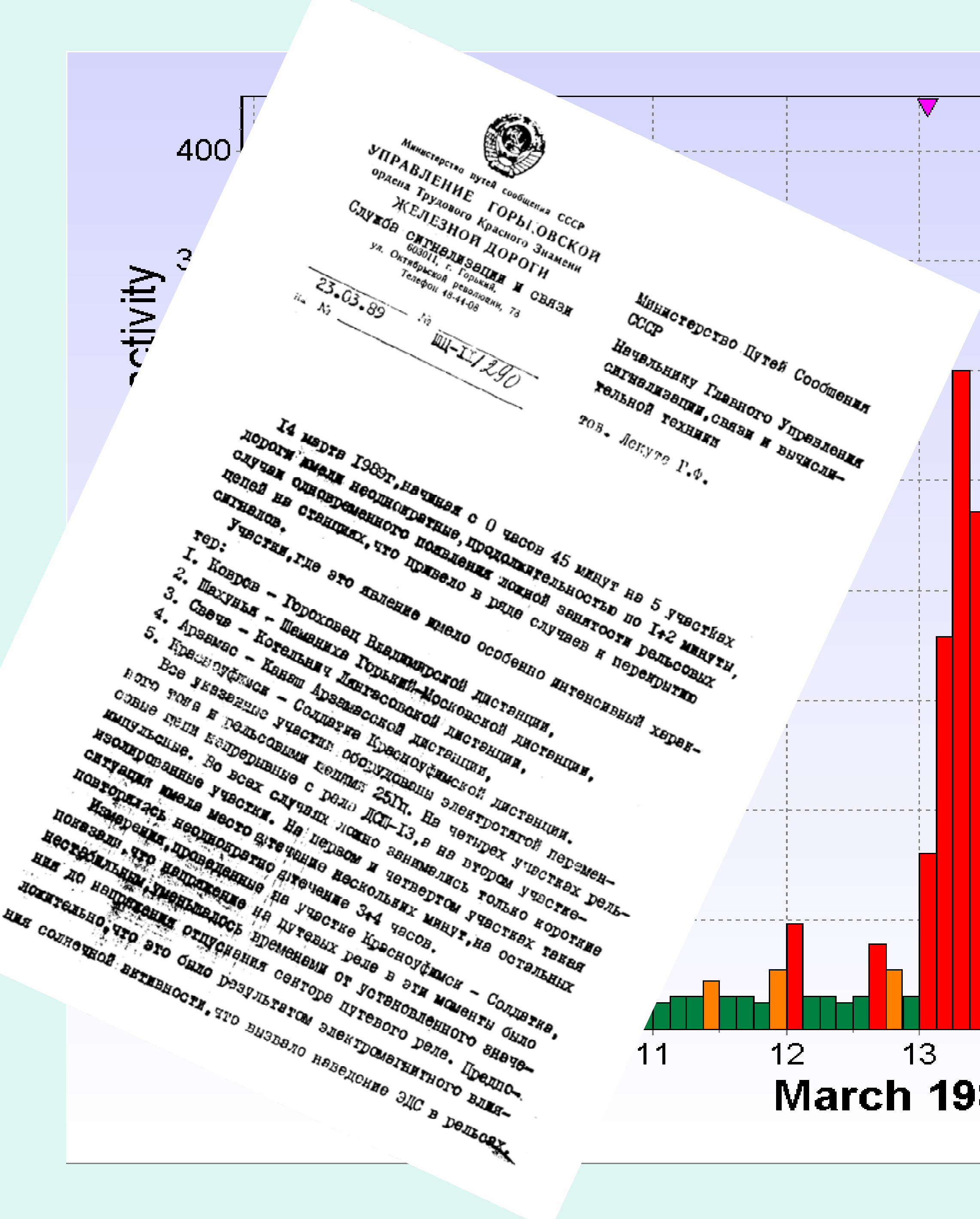
Nyandoma Distance of the Signalization and Connection, Northern rail way, Russia

ESWW-2, 2005

Last years IZMIRAN was receiving a lot of reports from Nyandoma part (63-64°N) of the Northern railway and Gorky railway about the cases of failure in the railway signalization, centralization and block (SCB) system at the number of railway stations throughout the period 1989, 2000-2005. They reported about some false signals at the duty tables regarding blockage on the tracks along the main railway that caused a delay in the train moving. The time and anomaly characteristics are put in protocols. It is characteristic that checking of the apparatus after these anomaly signals indicated their properly functioning. Comparison of the received reports with the data on the geomagnetic field variations revealed well pronounced correlation between anomalies in the railway automatics and big disturbances of the geomagnetic field during the greatest magnetic storms in these years.

A more detailed analysis indicates a coincidence between the time of anomalies and the most active geomagnetic periods with accuracy up to hours. It is noteworthy to emphasize that these periods were selected by the information on the railway, but not by geophysical situation. We did not receive any information on similar problem in the quiescent periods. The reason of these phenomena may really be the currents induced in the system of railway automatics. They seem to be occurred often enough at high latitudinal railways where throttle transformers included in the automatic signalization system




Министерство путей сообщения СССР
УПРАВЛЕНИЕ ГОРЬКОВСКОЙ
ордена Трудового Красного Знамени
ЖЕЛЕЗНОЙ ДОРОГИ
Служба сигнализации и связи
603011, г. Горький,
ул. Октябрьской революции, 78
Телефон 48-44-08
23.03.89 № ШЦ-1/1290

Министерство Путей Сообщения СССР
Начальнику Главного Управления сигнализации, связи и вычислительной техники
тов. Лекуте Г.Ф.

14 марта 1989г, начиная с 0 часов 45 минут на 5 участках дороги имели неоднократные, продолжительностью по 1÷2 минуты, случаи одновременного появления ложной занятости рельсовых цепей на станциях, что привело в ряде случаев к перекрытию сигналов.

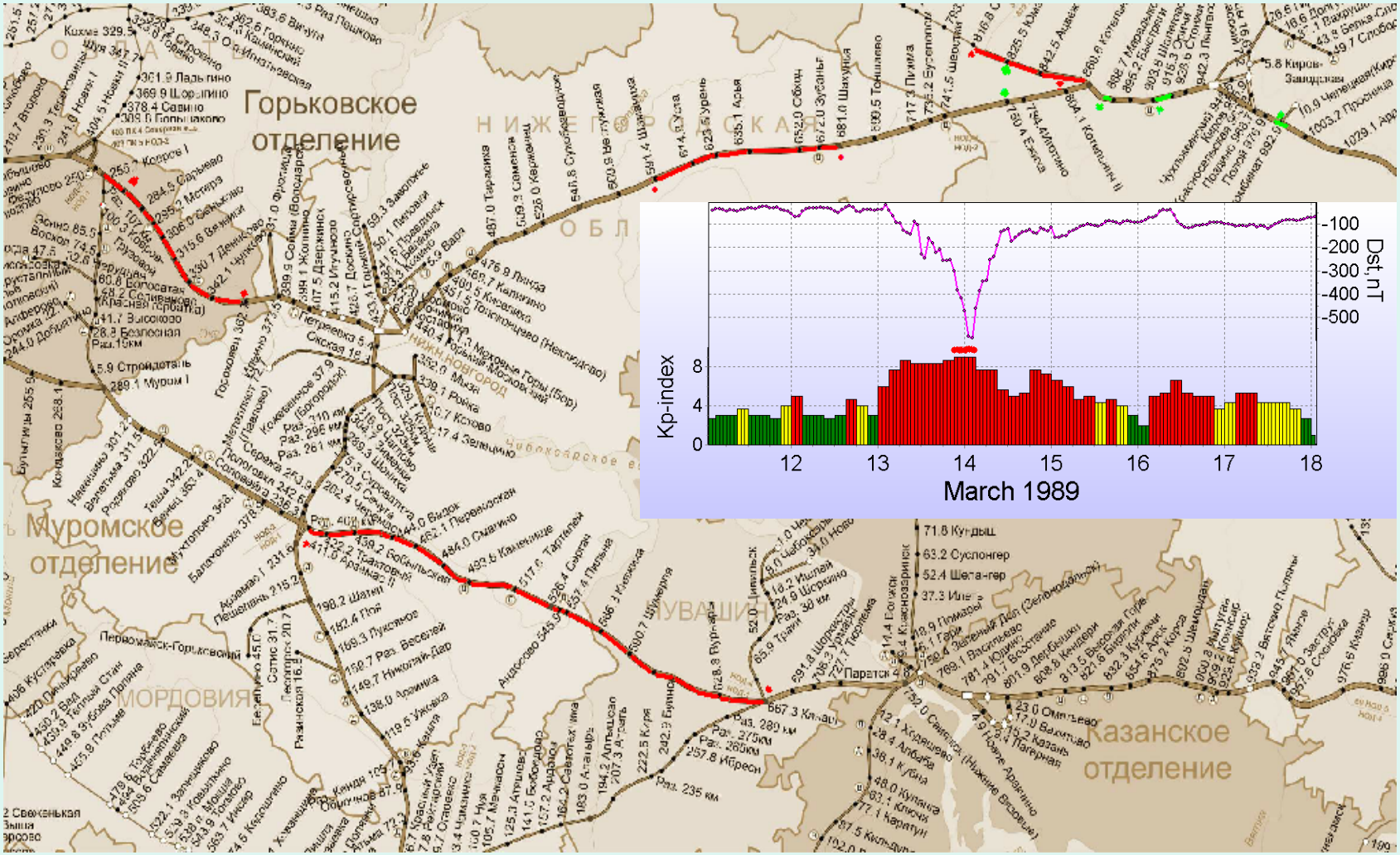
Участки, где это явление имело особенно интенсивный характер:

1. Ковров - Гороховец Владимирской дистанции,
2. Шахунья - Шеманиха Горький-Московской дистанции,
3. Свеча - Котельнич Лянгасовской дистанции,
4. Арзамас - Канаш Арзамасской дистанции,
5. Красноуфимск - Солдатка Красноуфимской дистанции.

Все указанные участки оборудованы электротягой переменного тока и рельсовыми цепями 25Гц. На четырех участках рельсовые цепи непрерывные с реле ДСШ-13, а на втором участке - импульсные. Во всех случаях ложно занимались только короткие изолированные участки. На первом и четвертом участках такая ситуация имела место в течение нескольких минут, на остальных повторялась неоднократно в течение 3÷4 часов.

Измерения, проведенные на участке Красноуфимск - Солдатка, показали, что напряжение на путевых реле в эти моменты было нестабильным, уменьшалось временами от установленного значения до напряжения отпускания сектора путевого реле. Предположительно, что это было результатом электромагнитного влияния солнечной активности, что вызвало наведение ЭДС в рельсах.

Gorky branch of the railway. Rail distances where failures during the geomagnetic storms were recorded: red lines-March 1989, green marks-in October-November 2003.



Report to the Chief of the Main Department of the Gorky Rail Ways from the Service of Signaling and Communication from 23.03. 1989.

- On March 14, 1989, starting from 0:45 (local time, ~ 20:45 UT on 13.03) took place the numerous cases of appearance of 1-2 minutes duration signals about false blockage of the railway tracks. Especially intensively it occurred in the following parts of railway:
- Kovrov-Gorokhovets, Vladimir distance;
- Shakhunja-Shamanikha, Gorky-Moscow distance;
- Svecha- Kotelnich, Lyangasov distance;
- Arzamas- Kanash, Arzamasskaya distance;
- Krasnoufimsk-Soldatka, Krasnoufimskoj distance.
- All these sections are equipped by electric traction of variable current and rail chains of 25 Hz. Rail chains in the four sections are continues, with relay DSCH-13, and on the second section they operate in the pulsed mode. In the 1-st and 4-th sections the situation with false signal occurred during the several minutes, in all others sections it repeated numerous times during 3-4 hours.
- Checking in the section 5 (Krasnoufimsk-Soldatka) showed the voltage on the railway relays at these moments was unstable, it decreased sometimes down to level of slack off the relay.
- Under asymmetry of the rail way resistance (In the short length rail chains its level because of the different resistance in the throttle crosspieces and rail bars is much higher than in the long ways) and appearance of rectification properties in some not tight contacts (bars and bridges) the addition magnetize of throttle transformer DT-1-150 arises that leads to a decrease of the inlet resistance on the feeding and relay ends and to the voltage fall on the way relay.
- Simultaneously at that time on the 3-rd, 4-th and 5-th distances the anomalies in the communication devices were observed.
- I ask you to consider a possibility to protect SCB operating against the analogous phenomena.

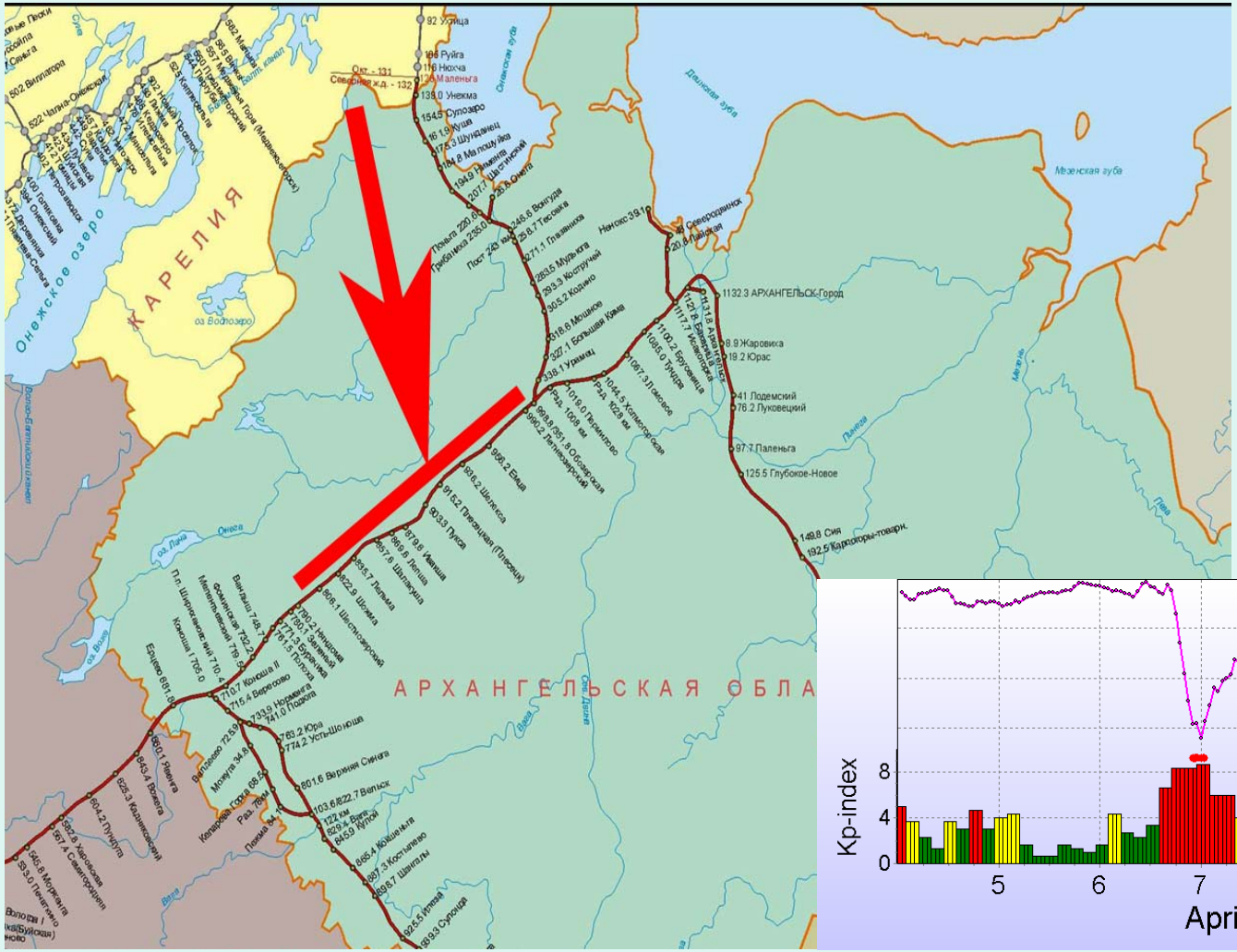
Chief of the SCB service V.A. Kasparov

Nyandoma railway division

Report from 10.04.2000 to the Chief of the Signalization, Centralization and Blockage (SCB) Service on the Northern railway Fedyaevu Yu. A.

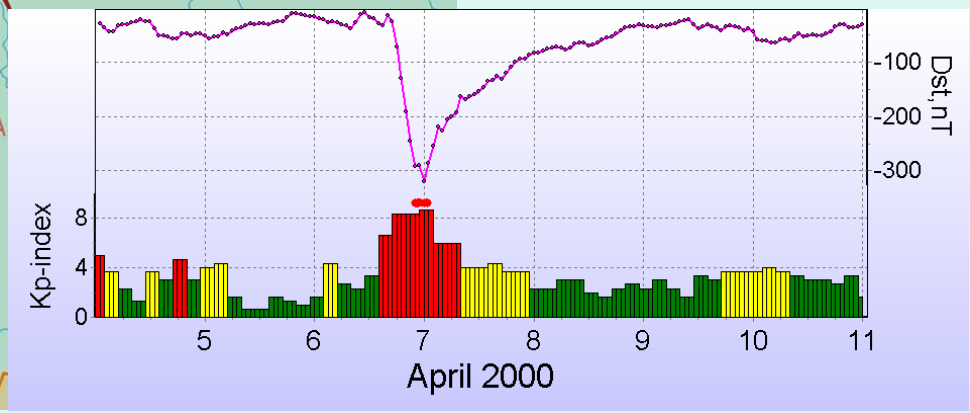
- In the night from 6 to 7 April 2000 the operating of rail chains in the section Nyandoma-Obozerskaya was very unstable. Below chronological sequence of the false rail chain occupation is presented:
- **1.1**. 6.04.00 21:47 LT. **Station Plesetskaya**. Short time false blockage of the rail chains NAP, NDP, 3-5 SP, CHAP, on the 1-st section of incoming by the odd way;
- **1.2**. 6.04.00 22:10 LT. **Station Shozhma.** The same rail chain 3-5 SP, 1-9 SP, NDP, 4-8 SP, 2-6 SP; **Station Lepsha**. NAP, 1-5 SP, 3-9 SP, CHAP, CHDP, the first sections of incoming ways;
- **Station Puksa**, the same rail chain NP, 2BP, 7 SP, 27 SP, CHP, 1AP, 10 SP, the first section of moving off by the odd way;
- **1.3.** 6.04.00, 22:25 LT. **Station Ivaksha**, rail chain 3-5 SP, 1-7 SP, 1 P, CHAP, CHAPD, 2-4 SP, 6-8 SP
- **1.4.** 6.04.00, 22:26 LT. **Station Sheleksa,** rail chains 1SP, 1/13P, 13 SP, 1P, CHBP, CHVP, CHDAP, CHDBP, CHDVP, 1 SP, 12-16 SP, 1-st section of moving off by the both ways.
- **1.5.** 7.04.00, 0:03 LT. **Station Ivaksha**, 3-5 SP, 1-7 SP, 1P, CHAP, CHAPD, 2-4 SP, 6-8SP.
- **1.6.** 7.04.00, 0:10 LT**. Station Puksa**, NP, 11 BP, 7 SP, 27 SP, CHP, 1AP, 10 SP, the 1-st section of moving off by the odd way, section of incoming 2PP.
- **1.7.** 7.04.00, 0:13 LT**. Station Shozhma**, 3-5 SP, 1-9 SP, NDP, 4-8 SP. 2-6 SP.
- **1.8**. 7.04.00, 0:14 LT. **Station Lelma**, NDP, 7 SP, the 1-st section of moving off by even way.
- **1.9.** 7.04.00, 0:15 LT. **Station Lepsha**, NAP, 1-5 SP, 3-9 SP, CHAP, CHDP, the first section of incoming by both ways;
- **Station Sheleksa**, 1 SP, 1/13 P, 13 SP, 1P, CHBP, CHVP, CHDAP, CHDBP, CHDVP, 2SP, 12-16 SP.
- **1.10.** 7.04.00, 1:03 LT. **Station Shalakusha**, 1/11 P, 11-17 SP, 4-12 SP.
- **1.11**. 7.04.00, 1:10 LT. **Station Plesetskaya**, NAP, NDP, 3-5 SP, CHAP, the 1-st section of incoming by the odd way.
- **1.12**. 7.04.00, 4:40 LT. **Station Yemtsa**, 1/11 P, 11-13 SP, CHAP, CHDP, 2-8 SP, 4-10 SP, 24 SP.
- **1.13**. 7.04.00, 3:50 LT. **Station Shestiozersky**, NDP, 1P, section of incoming, 1PP.

Anomalies in the railway automatic during the magnetic storms on the Northern Rail Way. Nyandoma distance.

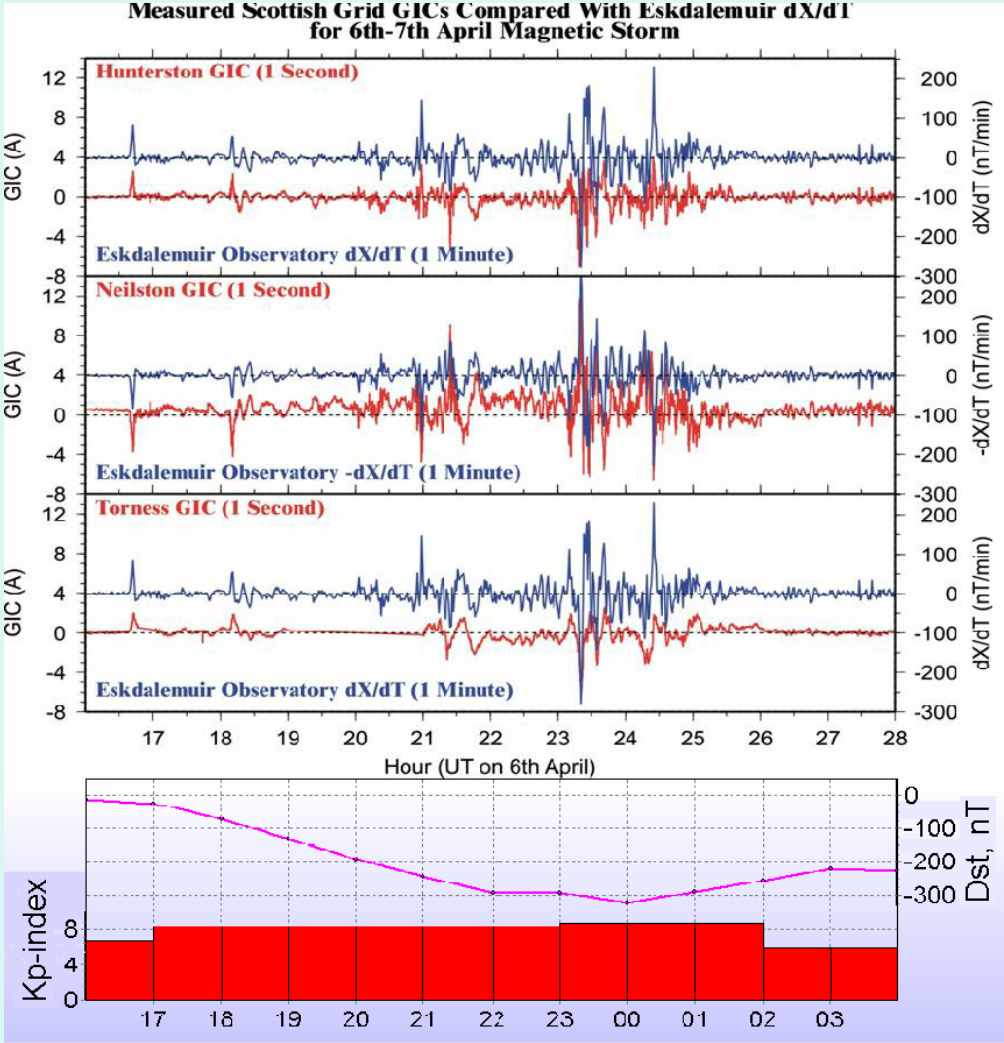


Stations:

Shozhma, Lelma, Shalakusha, Lepsha, Ivaksha, Plesetskaya, Sheleksa, Puksa, Yemtsa, Letneozerskaya, Shestiozerskaya.



GIC Monitoring during the Storm of April 2000, Kp and Dst indices, and failures in the railway operating



In the night from 6 to 7 April 2000 the operating of rail chains in the section Nyandoma-Obozerskaya was very unstable. Character of false blockage is of short duration, as a rule from several second up to minute. Rail chains were “occupied” unsystematically, one after another or several ones simultaneously. All blocked chains are placed along the main way. Anomalies in the SCB system started at the time of Kp increase – well before the strong GIC variations.

- **Character of occupation (blockage) is of short duration, as a rule from several second up to minute, the longest one was 3 minutes. Rail chains were “occupied” unsystematically, one after another or several ones simultaneously. All mentioned above chains are placed along the main way.**
- **Voltage on the feeders was in normal range. All stations and spans had been switched over to the second feeder, but signals on the false blockage were continued as before.**
- **Measurements on the rail relays showed “floating” voltage (deviation from normal 25V down to 6-7V). Under 9-10 V the relay was de-energized. The voltage on the exit of converters (the panels PP 25-ETSK) was normal and stable.**
- **Rail chains in all the stations are made by the album RC25-DSSH16-ET50-S-93, on the spans- by RC25-01P.**
- **The false blockage on the spans, except of the part of arriving and moving off, was not fixed, perhaps, because of the short duration.**
- **Checking of the rail chains and their voltage on the next day (07.04.2000) did not show any reasons for false blockage.**
- **Asymmetry of the traction current at the station Plesetskaya was higher than normal one (4%) on the rail chains 2PP, CHAP, CHDP, CH2U, NAP, 1PP (from 4.8% to 33%). At the rest station it was in the normal range.**
- **On this part of northern railway the system is applied of a contact net with shielding wire which is ground connected in every 5-6 km on the middle point DT, and at the stations it is ground connected near every input N, CH, ND,CHD.**
- **On the spans Ivaksha-Puksa-Plesetskaya-Sheleksa, Sheleksa-Yemtsa,on the stations Puksa, Plesetskaya, Sheleksa the spark intervals IMP-62 are absent. This is an explanation of the great asymmetry in traction current.**

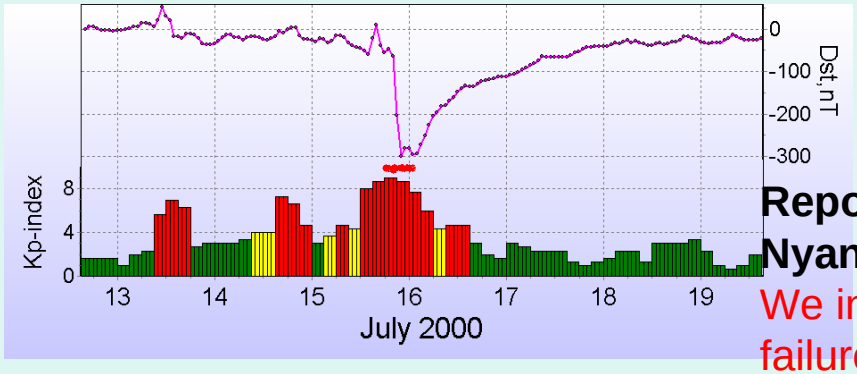
Deputy of chief on the SCB service
V. L. Lobkov

Report to IZMIRAN, Kanonidi Kh. D., from Nyandoma section of the Northern rail way, from 24.07.00

In the night from 15 to 16 July the situation of the 6 April was repeated. Please, confirm, if there was again the strong geomagnetic storm?

Chief of Nyandoma SH CH

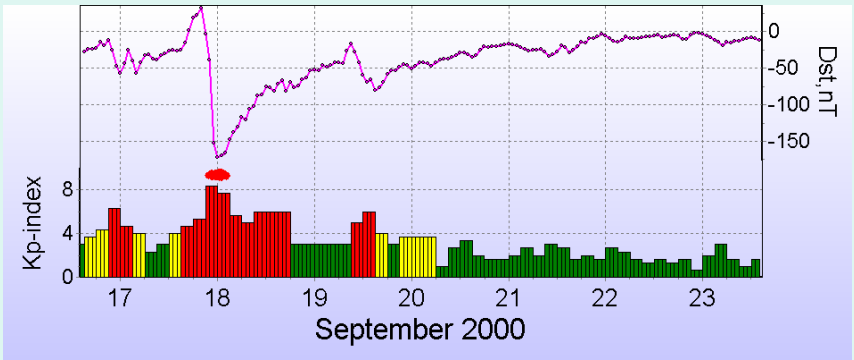
V.S. Zubkov



Report to IZMIRAN, Kanonidi KH. D.,from Nyandoma section of the Northern rail way.

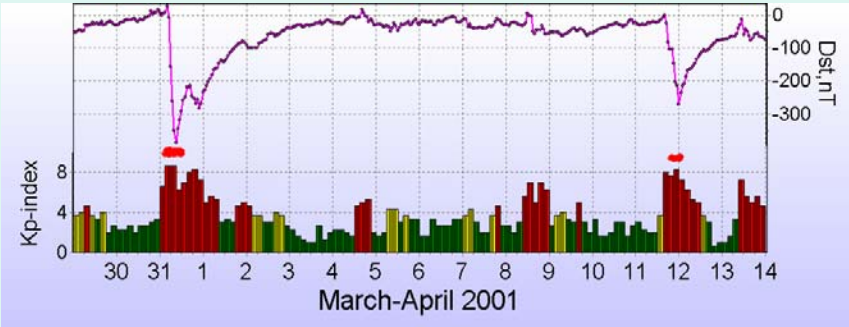
We inform you that on 18 September 2000 again the failures in the operating of electric rail chains were observed:

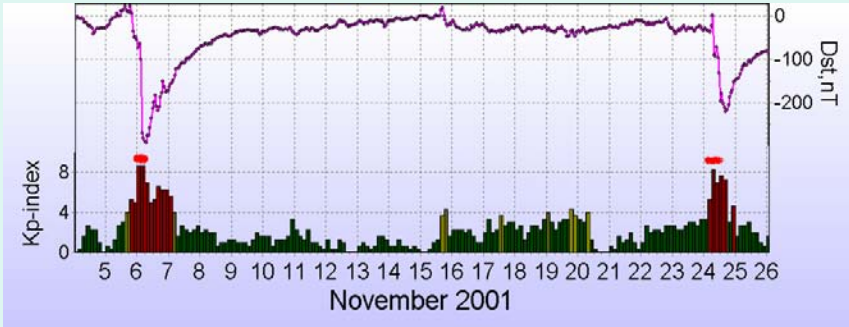
Station Lelma throughout the interval 2:10- 4:50 LT
Station Lepsha 7:35-11:45 LT
Station Ivaksha 0:43- 5:00 LT
Station Puksa 2:30- 8:10 LT
Station Yemtsa 4:10- 4:55 LT



The most number of failures occurred in the SCB devices on the station Ivaksha where unstable operating lasted up to 16 hrs (LT). Please, inform us on forthcoming storms, then, we shall concentrate the specialists and measure apparatus to define character of influence and points of SCB which are mostly exposed to the magnetic storm effect.

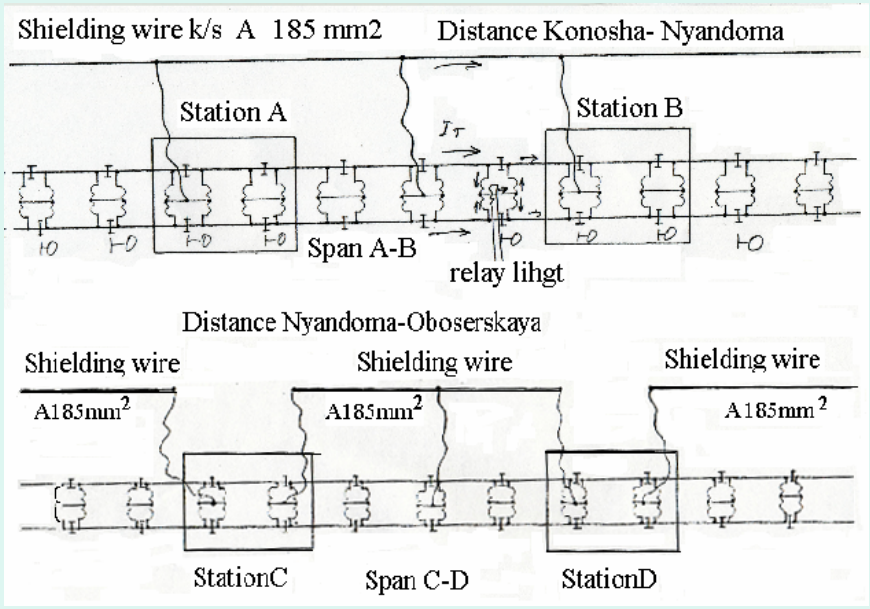
Report from 20.04. 01 to IZMIRAN, Kanonidi Kh. D.
Report from 27. 11. 2001 to IZMIRAN, Kanonidi Kh. D.

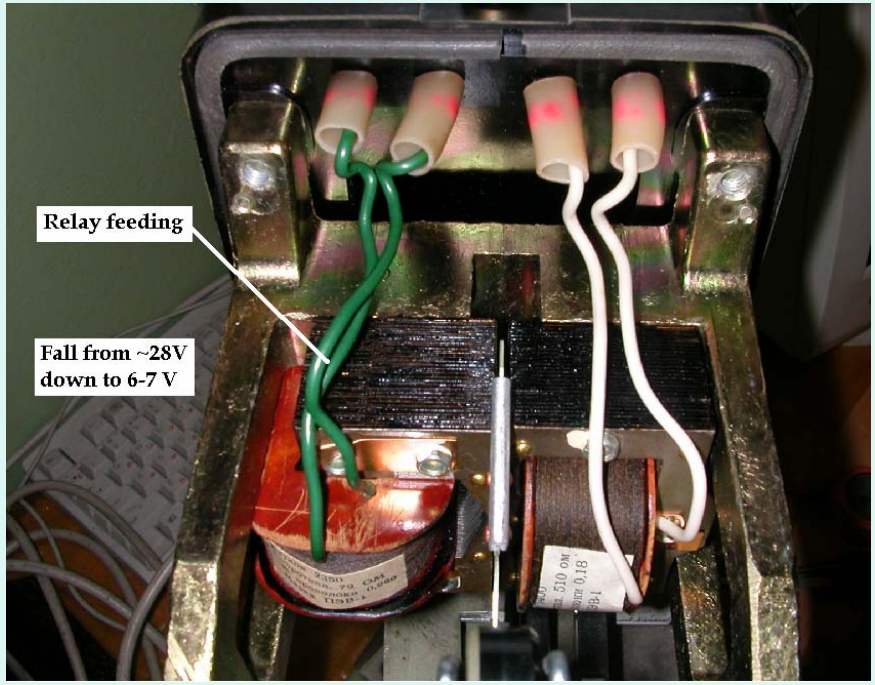


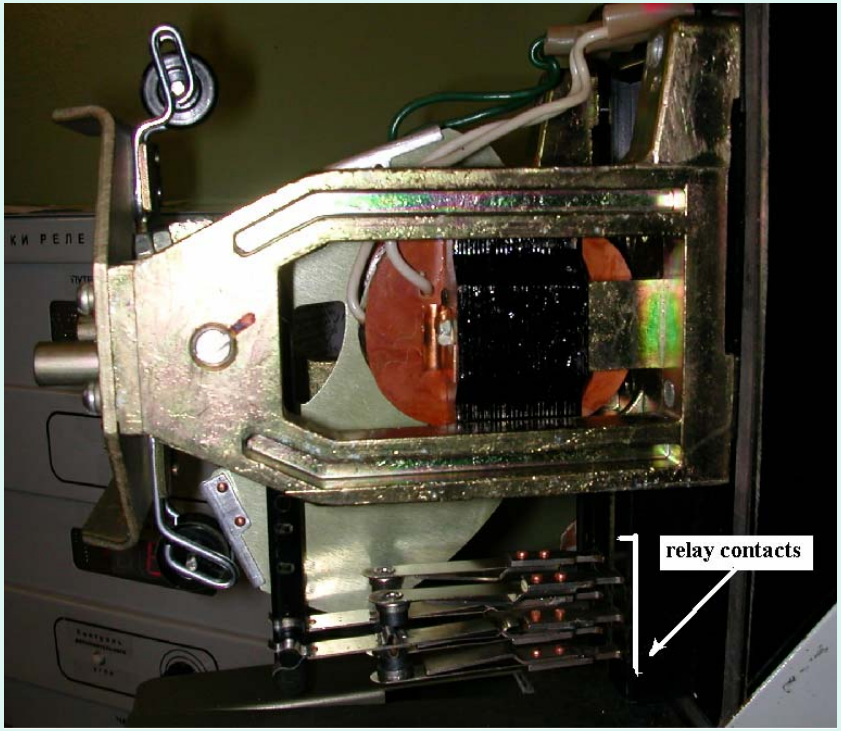


On 31.03.01, 08.04.01 and 11.04.01 the failures in the railway system SCB were observed at the stations Shestiozerskaya, Shozhma, Lelma, Shalakusha, Lepsha, Ivaksha, Puksa, Plesetskaya, Sheleksa, Yemtsa, Letneozersky. The anomalies revealed as unstable operating of the electric rail chains with current of 25 Hz.
On duty tables at different stations spontaneously appeared the false signals on the railway blockage. They appeared consequently: the red belt lights on the first rail chain, then on the second, third and so on. Along this the voltage on the feeders by the variable current was normal, but voltage level in the rail chain fell down: from normal 30V to 6V. The voltages changed also in the rails, both on the feeding and relay ends.

During the periods on 6.11.2001 and 24.11.2001 the failures occurred in the operating of SCB system because of the breach in operating of electric rail chains (25 Hz frequency) at the stations: Shozhma, Leljma, Shalakusha, Lepsha, Ivaksha, Puksa, Plesetskaya, Sheleksa, Yemtsa, Letneozersky.
We ask you to direct in our address a project of Agreement accordingly to which you could deliver to us a forecast on forthcoming magnetic storms.

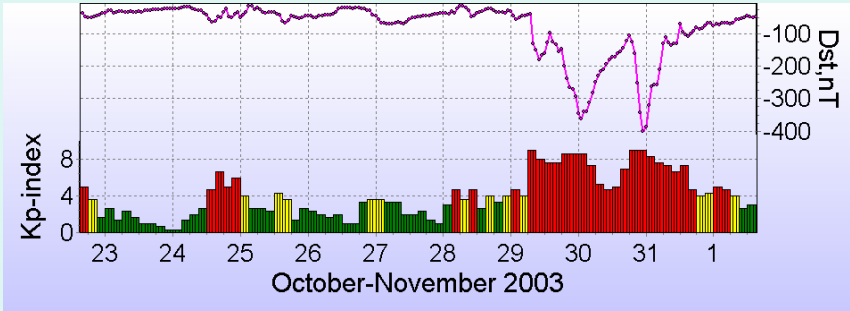






Block-scheme of the railway signalization system. In a distance Konosha-Nyandoma the shielding wire goes by transit way whereas along Nyandoma-Oboserskaya distance the shielding wire is broken at every station and the ends of wire contact middle points of DT-1-150. In result the reversal traction current is concentrated at the rail chains close to throttle transformer (DT-1-150) of the nearest traffic lights and the chains between of this station lights because of the absent shielding wire here. As a consequence DT works in overloading regime that leads to the fall of feeding voltages on the relay contacts and to their shorting.
Color pictures show throttle transformer DT-1-150.

Report of the railway laboratory of Automatic and Telemechanic on the study of failures in the rail chains occurred during the 29-31 October 2003 (Kirov branch).



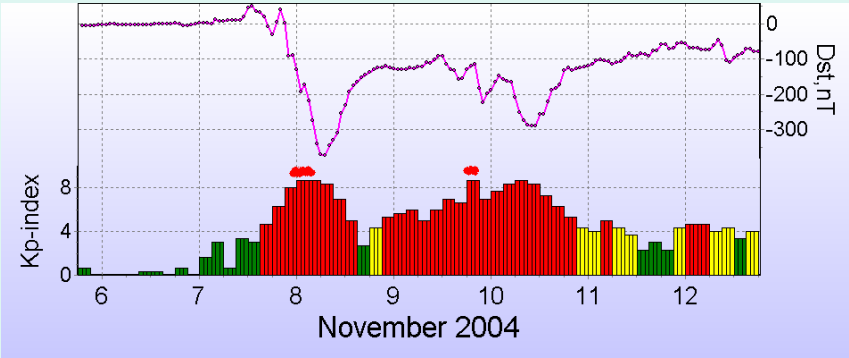
- **Failure characteristics:**
- There was a short time (around 1 minute) false blockage on the 14 rail tracks in the period from 22:15 LT on 29 October to 0:16 LT on 31 October. Chronology of anomalies is shown in Table.
- Mass failure in the rail chain operating is analogous to those under ice-covered phenomena on the contact wire. In present case, most probably, it is a result of induced electro-magnetic currents in the short rail chains. Under presence of even small asymmetry (within the norm limits) in the rail chains and with appearance of rectification properties by the parts of rail junction (crosspieces, bridges) these induced currents are sufficient for addition magnetize of throttle transformer DT-1-150. This leads to a decrease of resistance its main winding on the feeding or relay ends (perhaps on both also) and to the fall of voltage on a rail relay.

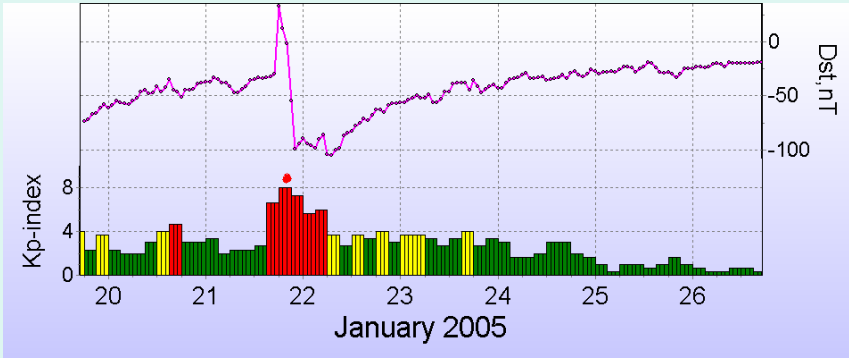
Table of the anomaly chronology in October 2003

N	Station	Date	Time(LT)	Relay name	Remarks
1	Glazov	29.10	22:15	21SP	Recovered
2	Orichi	29.10	22:18	6-18SP	Recovered
3	Bumcombinat	30.10	00:05	6SP	Recovered
4	Bumcombinat	30.10	1:34	6SP	Recovered
5	Orichi	30.10	1:05	6-18SP	Recovered
6.	Yuma	30.10	1:32	2SP	Recovered
7	Orichi	30.10	1:35	1SP, NDP	Recovered
8	Yezhikha	30.10	1:32	1, 5-9,8-12SP	Recovered
9	Maradykovsky	30.10	1:33	3-9SP	Recovered
10	Glazov	30.10	22:50	21SP	Recovered
11	Zuevka	30.10	22:50	72-80SP	Recovered
12	Bumcombinat	30.10	23:07	6SP	Recovered
13	Maradykovsky	31.10	00:16	3-9SP	Recovered
14	Yezhikha	31.10	00:15	1, 5-9SP	Recovered

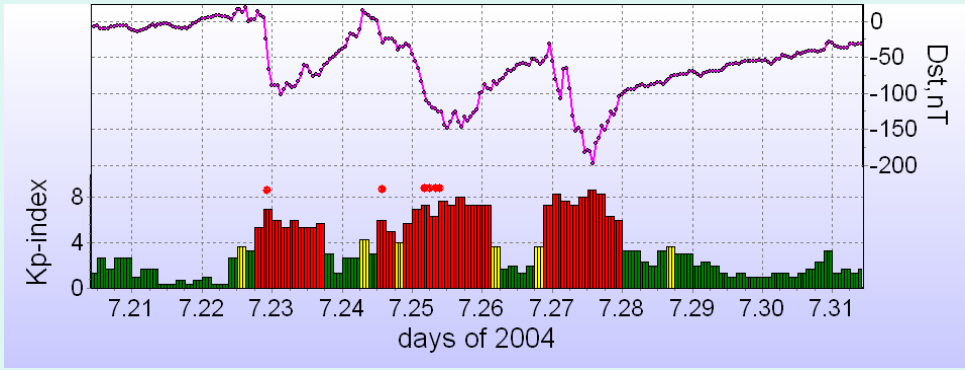
List of failures in the SCB devices in November 2004 and January 2005 (by the reports from Nyandoma section)

- **8 November 2004**
- Station Plesetskaya 02:15-2:48 LT. False blockage, rc CHAP
- Station Shalakusha-Lelma 02:40-3:13 LT. False blockage, rc CHAPD
- Station Puksa 02:56-3:41 LT. False blockage, rc 7SP
- Station Sheleksa 05:22-7:05 LT. False blockage, rc 1/13P
- Station Ivaksha-Puksa 9:45-10-35 LT. False blockage, rc 1/13P
- **9 November 2004**
- Station Sheleksa 22:50-23:55 LT. False blockage, rc 1/13P;
- Station Ivaksha 23:18-23:50 LT. False blockage, CHAPD, 2-4SP, 1-7SP;
- Station Lelma-Shalakusha 23:50-00:20 LT. False blockage, rc 1/13P, CHVP;
- Station Puksa 23:23-00:17 LT. False blockage, rc 10SP, 7SP, 13/19SP 13/19SP
- Station Plesetskaya 23:23-23:57 LT. False blockage, rc CHAP;
- From 23:20 LT the interferences were observed in the train and distance radio connection by the stations stations Shestiozerskaya, Shozhma, Lelma, Lepsha, Plesetskaya.
- **22 January 2005**.
- Station Puksa 01:19 LT. Short duration false blockage, rc 8-24SP;
- Station Sheleksa 01:19 LT. Short duration false blockage, rc 1/13P;
- Station Yemtsa 01:19 LT. Short duration false blockage, rc 2-8SP.

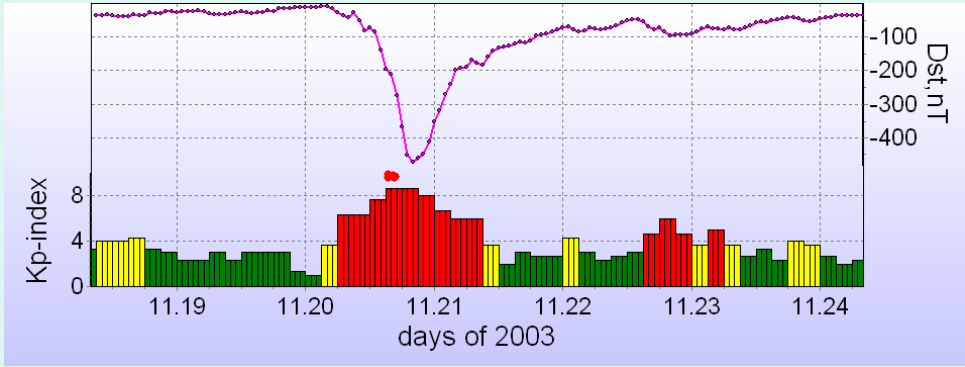




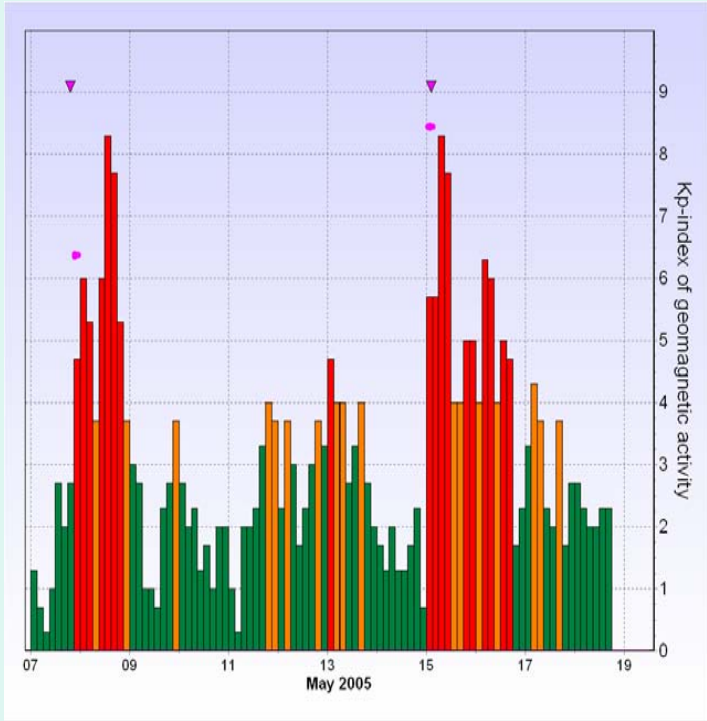
Additional cases of the railway anomalies during the stron geomagnetic storms in 2004 and 2005



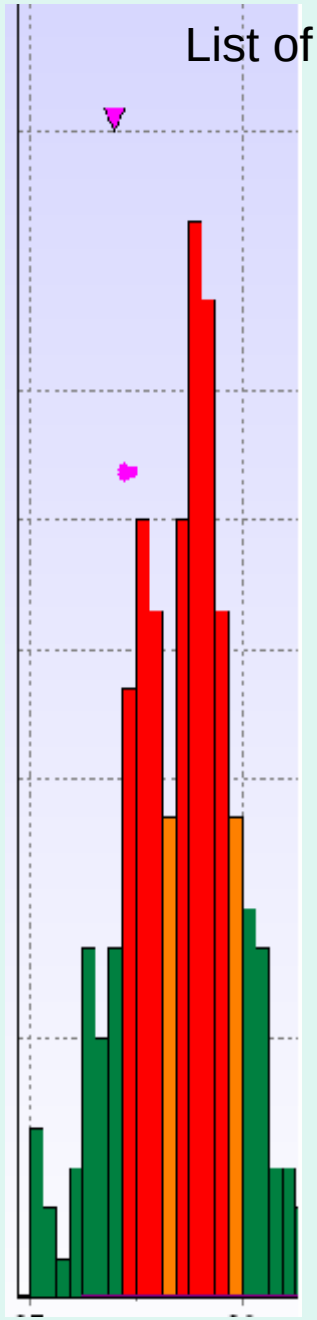
Puksa – 23.07 3:16-4:40; Shalakusha-Lepsha -23.07 3:10-4:00; Puksa 25.07 6:20-11:05



20 November, 2004. Puksa: 19:52-21:30; Lepsha: 19:37-20:05; Ivaksha: 21:11-22:46;

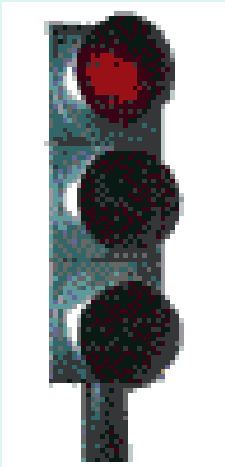


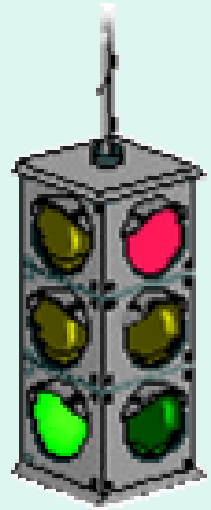
May, 08 2005: Burachikha- Polokha, 1:35-3:40 LT;
May,15 2005: Shalakusha-Lelma, Vandysh, 3:45-4:50



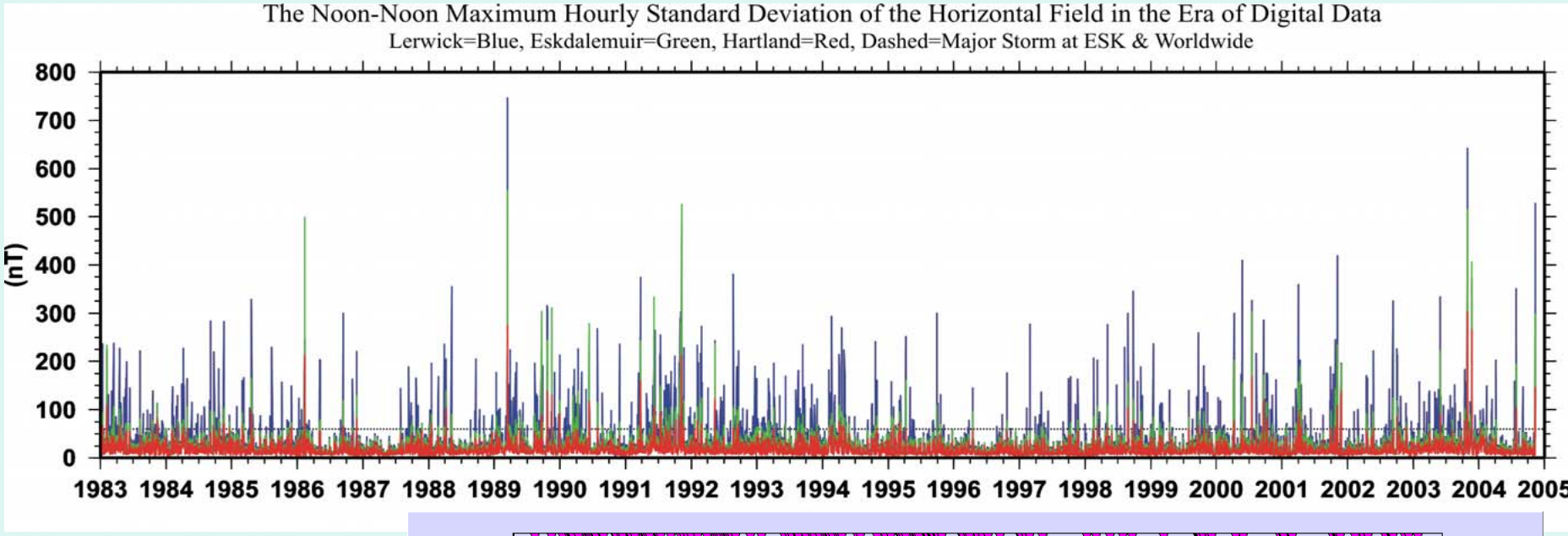
List of geomagnetic storms with anomaly effects in the railway operating

Date	Maximum Kp-index	Daily Ap-index	Minimum Dst-variation
March 13-14, 1989	9	246	-589
April 6-7, 2000	9-	83	-321
July 15-16, 2000	9	163	-300
September 18, 2000	8+	57	-172
March 31, 2001	9-	192	-358
April 8, 2001	7	63	-51
April 11, 2001	8+	85	-256
November 6, 2001	9-	242	-257
November 24, 2001	8+	104	-225
October 29-31, 2003	9	204	-401
November 20, 2003	9-	150	-472
July 23-25, 2004	8	154	-148
November 8-10, 2004	9-	161	-373
January 21, 2005	8	66	-105
May 8, 2005	8+	91	-126
May 15, 2005	8+	87	-256

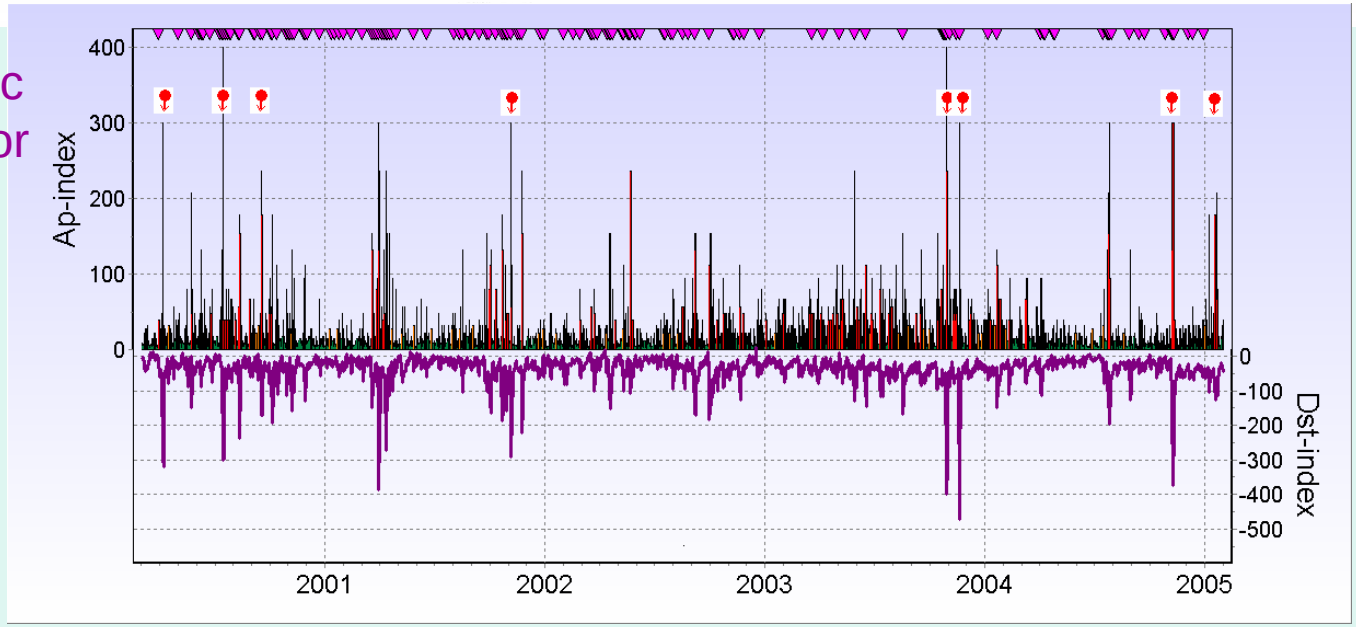




Historical GIC Activity Monitor (from 1983)



Indices of geomagnetic activity (Dst and Ap) for the period 2000-2005. Red markers correspond to the failures in the railway operating from Gorky and Nyandoma parts reported.



Rather far, but still Europe

Summary

During the periods of great geomagnetic storms throughout the 1989, 2000-2005 great number of failures was recorded in the northern railways.

- Failure characteristic was a short time (around 1 minute) consequence false blockage on different rail tracks that continued as a rule several hours during the active phase of geomagnetic storm and caused a delay in the train moving.
- Mass failures in the rail chain operating are analogous to those under ice-covered phenomena on the contact wire. Most probably, it is a result of induced electro-magnetic currents in the short rail chains which lead to a decrease of voltages on relay contacts from ~28 to 6-7V, and to the false blockage.
- Anomalies occurred during the strongest geomagnetic storms, under Kp=8-9. They started (with accuracy of 1 hour) in the maximum of Ap indices, but not in the minimum Dst, because Dst characterize equatorial disturbance, but Ap reflect better disturbances at the high latitudes.

- Some offers were suggested by the SCB laboratories to avoid such effects: exchange of throttle transformers DT-1-150 by the DT-0.6-500C in the zone of traction sub-stations; replace steel throttle bridges by steel-cuprum ones, and made these bridges of single length and section in the rail chains shorter than 300m to minimize asymmetry in the rail chains, or, put fully transit shielding ware through the distances where it is broken now.

The information was analyzed within the area 58-64N, 40-50E. Similar effects apparently may be observed at the other northern railways.