History of Rocketry and Astronautics

Proceedings of the Thirty-Fourth History Symposium of the International Academy of Astronautics

Rio de Janeiro, Brazil, 2000

Otfrid G. Liepack, Volume Editor

Donald C. Elder, Series Editor

AAS History Series, Volume 30

A Supplement to Advances in the Astronautical Sciences

IAA History Symposia, Volume 20

AAS Publications Office
P.O. Box 28130
San Diego, California 92198

Affiliated with the American Association for the Advancement of Science
Member of the International Astronautical Federation

First Printing 2009

ISSN 0730-3564

ISBN 978-0-87703-549-7 (Hard Cover)
ISBN 978-0-87703-550-3 (Soft Cover)

Published for the American Astronautical Society
by Univelt, Incorporated, P.O. Box 28130, San Diego, California 92198
Web Site: http://www.univelt.com

Printed and Bound in the U.S.A.

Chapter 6

Baikonur Tragedy*

L. V. Andreyev and S. N. Konyukhov†

In the *Guinness World Records* section "Catastrophes: In Air, on Land, and on Sea," the following statement appears: "The greatest space catastrophe on Earth took place when during fueling at Baykonur in Kazakhstan on the 24th of October, 1960, an R-16 rocket burst, killing 91 persons."[1]

Forty years have passed since the moment when this sad event in the history of rocketry took place. Despite this fact, there is still no full and thorough analysis in the open literature of all the factors and causes that led to the catastrophe. More than that, the press repeatedly deals with various subjective versions with the most improbable hypotheses. Even in the information from the *Guinness World Records*, there is a certain discrepancy.

The authors, for the first time, performed a comprehensive full-scale investigation on the basis of original materials that became public, departmental publications, and evidences (more than 20) of the participants of the event that took place on 24 October 1960.

The situation at the launch site and the preceding events were reviewed in addition to the circumstances that resulted in the issue of an unauthorized command on the second-stage engine startup half an hour prior to the start. The error made during the flight cyclogram formation was unambiguously determined. It is

---

* Presented at the Thirty-Fourth Symposium of the International Academy of Astronautics, Rio de Janeiro, Brazil, 2000.

† The authors are associated with the Yuzhnoye State Design Office, Dniepropetrovsk, Ukraine.

shown that if not for the fatal concurrence of circumstances, which was a direct consequence of an underdeveloped and unauthorized control system, unauthorized launch would have never been implemented. All the events since the moment of the catastrophe, until a successful launch in February 1961, will be thoroughly examined.

In Moscow the information about the first launch of Chief Designer M. Yangel's intercontinental ballistic rocket based on storable propellant components from the Tyuratam launch base (the name of the Baikonur launch base before Cosmonaut Yuri Gagarin's flight) had been anticipated for two days. In the evening of 24 October 1960, the Kremlin special communication link device printed the tragic cipher message, stating that 30 minutes before launch time during the final operation "the fire occurred leading to the propellant components tanks destruction, there are a lot of victims..."[2]

For a long time in the Soviet Union, everything that had something to do with this accident was treated as top secret. The death of the chief marshal of artillery was described without any explanation, except as an airplane accident. Some information about the accident penetrated to the foreign mass media, however informational sources of the Soviet Union kept silent.

Only recently, when the documentation relevant to this tragedy was declassified, the real reasons and consequences of the event became known. The fire was a reason for the death of 57 military men and 17 representatives of the industry. Moreover, 49 people were injured and taken to hospitals—16 died in the hospitals from burns and poisoning. This is the scale of the tragedy.

What happened at the launch base on 24 October 1960? Preparation of the R-16 rocket for launch (SS-7) was conducted with an implicit competition in founder of the Soviet Union space program S. Korolev's design office, whose intercontinental rocket R-9 (SS-8) passed the preparation for launch with a delay of schedule at the same launch base.

The R-16 rocket launch was scheduled to take place on the morning of 23 October. On the morning of 21 October, the rocket was transferred to the launch site and installed on the launch pad. From 21 October to 23 October, the rocket preparation for launch was performed according to the technical documentation. Autonomous and integrated tests were conducted with the aim to verify the reliable joint operation of the systems. There were no major remarks indicated during the tests. After this, the rocket was fueled with the propellant components, compressed gases, and the pre-launch preparation started. The launch was scheduled for 23 October in the evening. Final operations of the pre-launch preparation were at the completion phase and, as stated above, there were no major remarks. The strain became higher. The first anxious signal happened at 6:00 pm. The emergency situation that arose—echoing Hamlet's question "To be or not to be?"—occurred while conducting the pyro-diaphragms breach operations. Instead of the second stage oxidizer line pyro-diaphragms, the first stage fuel pyro-diaphragms were breached. The reason was because of the failure of the voltage supply main distributor. Replacing the main distributor for a good one on the fueled rocket, with the breached pyro-diaphragms and activated onboard batteries, was risky. However this was done.

But what should be done with the rocket? According to the specifications for tightening, cuffs, and spacers, the rocket could be left standing fueled for just 24 hours. In case of the launch being canceled, the propellant components would be offloaded, and the rocket sent to the manufacturing plant for reassembly. The decision was made to repair the rocket at the launch pad. This was the end of the day of the scheduled launch date.

The day of 24 October was full of activities directed toward elimination of malfunctions. There were a lot of problems due to the need to define conditions of the propellant lines after the separating pyro-diaphragms breach. Moreover, the inadequate electronic anti-counter measures of the coded pulses amplifier were detected. Such a malfunction would require a long time to be solved. After specialists' discussions, control system Chief Designer B. Konoplyov made a decision to launch the rocket without any additional modification of the coded pulses amplifier. In order to eliminate the possibility of "false commands," the decision was made to initialize the step-type motors of the control system when the 30 minute readiness for launch would be announced. This was a fatal decision.

In the evening, the personnel completed operations of the rocket preparation and were evacuated to the observation post, located at a distance of one km from the launch site. These are the words of a specialist who was at the observation post: "Delays started [being] announced through the loud speaker. But suddenly—blaze! The cries: 'Launch, launch!' What a launch if the erector was not still withdrawn ..., and after—people burning are falling heavily to the ground."[3] The people standing close to the rocket saw the plume near the second-stage aft bay.

Soon the situation should clear—the second-stage main propulsion system started up. Its plume burned the bottom and destroyed the first-stage oxidizer tank, and after that the fuel tank leading to the rocket structure was destroyed. In the second stage engine operation, 120 tons of propellant components mixed and explosively inflamed. When the solid propellant motors of the stages separation started, the air balloons of the tank's pressurization system exploded. The resulting fire, accompanied with ominous fireworks, turned the launch site into a volcanic hell. An explosive afterburning avalanche speeded more than 100–120 m away from the launch point. The fire that took place after the propellant components burned out lasted two hours more. Propellant components that splashed out from the rocket tanks poured on the people standing close. The fire consumed people instantly. Toxic vapors poisoned personnel to death. Escaping people tried to run away from the burning rocket, but the high temperature burned their clothes. People were stuck like torches in the melted bitumen, even at a considerable distance from the fire epicenter. The fiery tornado killed Chief Commander of Rocket Forces Marshal of Artillery M. Nedelin and Chief Designer of the control system B. Konoplyov.

The special state commission quickly defined a reason for the unauthorized start-up of the second-stage main engine. The second stage current distributor flight timeline, after all the commands, contained a tragic command that led to the premature start-up of the second-stage main engine. This was a fault of the control system.

But what happened at the launch site during the rocket preparation for launch? The first reason that led to the second-stage main engine start-up was a premature breach of the separating diaphragms of the second-stage propellant tanks that took place on 23 October.

The second reason was that it was a mistake to activate the second-stage power sources. According to the standard technology, the self-activating batteries should be operated by compressed air-pressure (3–4 bar) after all the checks during lift-off, when there are no people around the rocket.

Finally, the third and decisive mistake was the primary reason after the previous two incompetent decisions. After the last cycle of the integrated testing, the control system should be initialized. By that time the pyro-diaphragms of the fuel and oxidizer lines of both stages had already been breached and the power supply sources activated.

Just before the system initialization, the propulsion systems automatics equivalents were detached and the rocket cabling was connected according to the flight configuration. Of course it can be assumed that such a step was allowed, based on the willingness to obtain initial status of the control system before the launch and, at the same time, to verify normal attachment of connectors. During the second stage, step-type current distributor initialization the "false" closing of the claw happened, leading to the actual start-up of the second-stage propulsion system. At that time the rocket was standing on the launch pad completely ready for launch.

Many specialists investigating the reason for the accident questioned whether it was possible to avoid this greatest catastrophe of rocket technology.

This is the answer: if everything had been done according to the initial technology without any deviations during the rocket preparation for launch, that is, the step-type current distributor, initialization would not have been performed in a flight configuration. But the equivalents of the schematic error would not have appeared at future launches, would have remained a secret, and would have caused the R-16 decommissioning due to moral depression. The one small thing that was needed for this was the appropriate point in the instructions forbidding any operations after the onboard power supply activation.

So the original reason was a schematic mistake of the control system designer, in particular "false" closing of the second-stage main propulsion system pyro-starter ignition command claw during the system initialization after the integrated testing.

A technology of the integrated testing will be briefly considered now. The integrated testing purpose is to check and estimate the entire sequence: readiness, launch command, further commands for the control and main engines start-up, lift-off switch, control system commands, transmission to the actuators, and other commands up to the main one for the second-stage engine shut-down and the warhead separation.

In order to conduct the integrated testing, the automatics cables were detached from the first- and second-stage commutation instrumentation and replaced by the automatics equivalents cabling. Commands transmission from the control system was monitored by turning on the corresponding buttons. The integrated tests were considered as completed after the main command and appropriate reports were issued. The schematic stopped because of the power supply after the main command transmission had been prepared for initialization. After that, during initialization, the circuit was powered and all the components were initialized, including the current distributors of the first and second stages through the dedicated contacts.

There are at least two questions that arise. First, why was the "false" closing of the second-stage current distributor claw not detected at the integrated bench of the developer or at the control and test facility of the manufacturing plant where the integrated tests of the control system were performed?

The fact is obvious that the control system malfunction was not anticipated during the initialization, so the control buttons were not monitored properly. The corresponding instruction of the manufacturing plant control and test facility has a separate record: during the system initialization, the control button activation can be free of the monitoring. Most likely such a record was automatically put into the developer test documentation.

Second, why did the "false" closing of the second-stage current distributor claw lead to the accident at the launch pad? It is the same answer—it was the fault of the operations logic flow (technology). Nobody anticipated any surprises from the control system during such operations as initialization after a clearly performed pre-launch and flight timelines. Trying to obtain at least an indirect verification of the connection correctness, the decision was made to disconnect equivalents and to use real hardware in order to initialize the system. After that, the situation occurred that led to the catastrophe.

The original reason is clear, factors initiating the catastrophic consequences are clear also. But the following should be understood: if the corresponding factors would not have been implemented, that is, the circuit initialized with the use of equivalents according to the documentation, then nobody would have known that the second-stage current distributor claw "false" closing existed. Moreover, the rush to perform the initialization operations increased the scale of the tragedy. If this operation would have been one of the last, when almost all pre-launch activities had already been performed (including detachment of different systems from the launch vehicle), then there would be fewer people near the rocket. All the personnel would have to leave the launch area when the 15 minute launch readiness was achieved.

The answers to the questions—whose mistake was it and who could have prevented it—are clear: individual mistake, collective responsibility. A responsible person can make a mistake, but it should be found by everybody involved in the multi-stage process of the system development.

Both civil and military specialists were testing the control system carefully at the control and testing facility of the rocket manufacturing plant and inside the launch base assembly and test facility during the pre-launch preparation. But they were looking for possible deviations or abnormal operation within a shaft turn angles (where the control system should condition the commands during the launch and flight), not within a blank sector of the timeline where there were no checks foreseen by the instruction.

This is such an unusual situation that, after already tens of years, a lot of people treat the accident reason as just the false command issued during the step-type current distributor initialization, but they do not know all the circumstances leading to the accident occurrence and why the reason was not detected during the multiple testing.

This is a sequence of events that happened at the launch area, and led to the catastrophe with the largest number of human victims. So 24 October 1960 became a "black day" of the launch base history. But this was not the end. One more tragedy happened at the launch base on the same date three years later on

24 October 1963 during S. Korolev's R-9 rocket preparation for launch from the silo launcher. During the bulb replacement in the gas-laden atmosphere of the silo (due to the fuel spillage) a fire occurred that led to the death of eight specialists.

After the state commission work was completed, the decision was made to return the second R-16 rocket to the manufacturing plant for elimination of defects. Later the rocket was shipped to the launch base and successfully launched on 2 February 1961.

Notes and References

[1] *Guinness World Records 2008* (Morganville, New Jersey: Guinness, 2007).

[2] Kremlin Communication (24 October 1960).

[3] Baikonur Cosmodrome (24 October 1960).