Historian's Corner

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A Mishap at Marysville
By
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Back in 1963, an astounding event occurred in a Titan I ICBM located in an operational silo at the T-5 Missile base near Marysville, California. It was similar to two previous events at other bases however it was found to be essentially unrelated to their problems. The vehicle was under U.S. Air Force control and had been on active standby subject to appropriate orders to launch. The RP-1 propellant tanks were full, and a live warhead was in place atop the missile. The missile was located on the elevator at the bottom of the silo.

Several maintenance activities were in process, both in the vehicle and in the ground based power system. Technicians were working both in the missile guidance bay, and at the lower level of the silo where a set of batteries was located. Suddenly, with no command or warning, the two stage separation rockets located at the bottom of Stage II ignited, the separation bolts holding Stage II securely to Stage I fired, and Stage II lifted off Stage I. Seconds later when the rockets burned out, Stage II settled back onto Stage I. Fortunately, Titan I Stage I had two guide rods that extended up into Stage II about five feet to assure a smooth, in-flight stage separation with no mechanical interference. This was prior to the "fire-in-the–hole" stage separation scheme used for Titan II. These rods kept Stage II in line with Stage I so it sat back down in its normal position.

It was understood that a technician was working in the missile guidance bay when the event took place, and who must have had a few terrible seconds, wondering if he was going to be launched. The roar of the rockets firing was also no small matter since they were each 5000 pound thrust rocket motors that burned for 2.8 seconds. In all, no one was seriously hurt, although some structural damage was suffered by each stage from the impact of Stage II falling back onto Stage I.

I was assigned the task of assembling a team of engineers to: evaluate the problem, find the cause, and initiate whatever action was required to prevent a future occurrence. The team consisted of four or five people, including: Duane Newell, Bill Cielinski, Dave Waddington, and one or two more whose names I cannot remember. We started the investigation with a review of the sequence system electrical schematics, and concluded that if everything was as shown, there was no way it could have happened. Several safety details were included in the circuit design such as: shorting circuits across the bridge wires of the ordinance items, open circuits at the sequencing relays, and including a safety switch operated by a lanyard attached to the silo wall that prevented any staging sequence circuit to be activated. It soon became apparent that a quick solution was not going to pop up.

Dave Waddington was a brilliant engineer with a reputation for unconstrained deep thinking. Duane was the engineer for the Titan I electrical sequence system and knew the circuitry by heart. It puzzled everyone for a day or so until Dave said we needed to get out the wiring diagrams to see exactly how the system schematic was implemented in the vehicle wiring. These diagrams show how a particular wire is routed, exactly what connectors and pin numbers the circuit passes through, and what terminal boards and pin numbers are used. Sometimes the path of a given wire might travel through several different terminal boards to finally reach the place in the vehicle where it is needed. These boards usually have many small threaded studs in close proximity where wires with eyelets are held tightly in place by small hexagonal nuts.

Dave spent another day studying the diagrams and came up with minimal new ideas; however, he said if this wire was here, and that connection was there, and there was a bad connection here, there would be a slight chance that this event could occur. This required a circuit path that went into different, unrelated circuits, and was such a low probability that he almost didn't mention it. No other ideas were brought up.

The team gathered up diagrams, oscilloscopes, circuit breakers, voltmeters, and other electrical tools, and went to the T-5 site. With the help of several airmen at the site, we learned that the event started when a technician working on the vehicle dropped a wrench, and it fell to bottom of the silo. At the same time a technician working on the ground power system had removed the cover over a 28 VDC battery pack located there. The wrench landed across the plus and minus terminals of the battery and resulted in a short circuit and a large electrical spark. It apparently also sent a 28 volt power surge into the ground power circuit that was connected to the missile. That power surge was likely the cause of the event, but the problem now was to determine if and how it found its way to the missile stage separation ordnance.

The first activity was to see if we could duplicate the event. A circuit breaker and a switch were installed between the ground and the positive side of the battery pack to duplicate the short circuit that had occurred, and an oscilloscope was connected at one of the ordinance terminals to record any voltage that might find its way there. When the switch was closed, the short circuit occurred similar to when the wrench hit the batteries. The breaker quickly opened, however a voltage surge was observed at the scope and on the missile ground system, apparently as it did during the actual event. The problem was successfully duplicated. The task now was to find the path. The next activity involved conducting a series of preliminary tests and measurements previously defined by Duane and Dave.

These tests indicated that some issue existed with the missile grounding system. A surge like this should not be able to elevate the potential of the missile ground circuit since it was tied directly to a single point ground terminal connected directly to the silo system ground.
Climbing around the missile we tracked the appropriate wires from one vehicle terminal board to the next, measuring for voltage, checking for any crushed wire or other discrepancy that might have existed. Finally, going back to the unlikely scheme that Dave had postulated, every potential problem point was checked. The single point ground issue was found and resolved. Then we all went to the suspect terminal board, and found the specific terminal nut loose, just barely holding the wire eyelet on. Wow! What a piece of detective work by Dave. With a few minor fixes the problem was resolved and it should never happen again.

In the missile industry and aerospace engineering in general, there is a common theme in system design -- do not allow a single point failure to exist that can compromise the mission. This was provided for in this design. The amazing thing about this event was that it took five different, almost unrelated, situations to cause this to happen. The first was that the cover was off the battery pack at the floor of the silo. The second was the dropping of the wrench and it landing exactly upon the hot terminals of the battery pack. Number three was the vehicle single point ground situation, and number four the untightened nut on the terminal board. If any one of these items had not been present, it would have prevented the event.

Number five was that the safety lanyard pin was not installed as procedures called for (this was the most serious issue). Since an inadvertent firing such as this could have such serious results, the lanyard operated safety switch was included in the system. The pin was to be in place at all times after the missile was placed in the silo, and only be pulled as the missile was raised as the elevator rose in preparation for launch. Although it would be hard to even think up and design against a series of relatively innocent things that could have such an impact, but with the lanyard pin out, it could and did happen.