

**365 MAIN INC  
SAN FRANCISCO DATA CENTER**

**EVALUATION OF RESPONSE BY 365 MAIN INC TO  
GENERATOR FAILURE OF JULY 24, 2007**

PREPARED FOR  
**365 MAIN, INC.**



**SEPTEMBER 3, 2007**

## **I EXECUTIVE SUMMARY**

- A. EYPMCF was commissioned by 365 Main Inc to provide an independent verification of the root cause of the failure of the generator system at the 365 Main Street, San Francisco data center during the major power disturbance and outage on the PG&E system in downtown San Francisco on July 24, 2007.
- B. Following the utility outage, three of the facilities ten backup generators failed to start resulting in downtime to many of the facilities customers.
- C. EYPMCF specializes in the design, testing, commissioning, and evaluation of data centers and critical facilities and is familiar with the systems, equipment, and design of the electrical infrastructure similar to 365 Main Inc. It should be noted that EYPMCF has had no previous involvement with the system at 365 Main Inc.
- D. EYPMCF has evaluated the system and data available from the event, performed interviews with facility operating staff and engineers, representatives and technicians from Hitec and Cupertino Electric. EYPMCF has independently consulted with the engine and engine controller manufacturer to verify and validate the findings of Hitec regarding the cause of the generator failure.
- E. EYPMCF has concluded and is agreement with 365 Main Inc and Hitec that the cause of the failure-to-start was a programming incompatibility between the engine DDEC electronic controller and the Hitec QMS PLC generator system controller. The conflict only became problematic recently as the engine and equipment increased in operating hours and, therefore, was not present or detected during original acceptance testing or subsequent annual testing of the generators.
- F. A programming modification was performed to the Hitec QMS PLC, which controls the generator system, and extensive follow-up testing was performed confirming that the root cause was, in fact, detected and the corrective action was successfully implemented.
- G. In addition, additional monitoring of the engine DDEC controller by the Hitec QMS PLC was implemented to insure that the DDEC controller is ready and operational.
- H. In summary, it is the opinion and belief of EYPMCF that 365 Main Inc and Hitec responded quickly and responsibly to the equipment failure and were able to detect and correct the problem and have implemented safeguards to prevent this mode of failure from reoccurring.
- I. The following is a more detailed discussion of technical issues from our evaluation.

## **II SOURCE MATERIAL**

- A. Hitec Failure Analysis Report with attachments dated 8/09/2007
- B. Hitec Internal Technical Memo dated 8/02/2007
- C. Teleconference with 365 Main and Hitec on 7/31/2007
- D. Teleconference with Hitec on 8/24/2007
- E. Public domain technical information on the DDEC engine controller
- F. Public domain information regarding the PG&E power outage

### **III DETAILED ANALYSIS OF THE FAILURE**

- A. The cause of the problem, investigative and forensic procedures, and corrective action are all described in detail in the above referenced documents by Hitec and will not be repeated in this report.
- B. The problem as reported and described by Hitec is related to the DDEC controller of the Detroit Diesel engine powering the generator system. There is a very precise timing interval that must be properly sequenced by the Hitec QMS PLC to shut-down the engine after a run and initialize the DDEC's for the next operation without causing a complete system reboot. A complete system reboot takes considerable time and causes an extended delay in the next start sequence, which cannot be tolerated by the Hitec design.
- C. The OFF time delay in the ignition circuit must allow for the engine to completely spin to a stop and then an initialization process must be completed by the two DDEC controllers per engine. If the ignition signal is re-applied before the initialization process is complete, the initialization process may be corrupted and controller may fail to start the engine or the engine may start but not operate properly at the next engine start signal. If the OFF time delay signal exceeds 30 seconds, the DDEC performs a complete reboot and no longer knows the position of the engine and several additional cranking revolutions are required on the next start cycle to sync the DDEC's with the engine. These additional cranking revolutions are not acceptable with the very rapid engine start (2 seconds) required by the very nature of the Hitec design.
- D. The Hitec machines using the Detroit Diesel engines with the DDEC controllers in 60 Hertz applications were designed, built, and tested with a 10 second time delay. The ten-second-time delay was adequate for successful operation of new equipment. As the engines become broken-in, the spin-down time increases to the point where the 10-second time-delay is not adequate, the ignition signal was re-applied before the initialization sequence was complete and, therefore, the next re-start may not be successful. This was the condition on July 24, 2007 when 3 or possibly more units failed to start during an actual power outage.

### **IV CORRECTIVE ACTION**

- A. 365 Main Inc and Hitec performed exhaustive investigative analysis into the cause of the failure to start which is detailed in the Failure Analysis Report prepared by Hitec. EYPMCF rarely sees such a comprehensive and well-documented analysis in these situations. Their analysis eventually closed-in on the cause described above.
- B. To overcome the time-delay compatibility problem, Hitec increased the ignition signal OFF interval from 10 to 15 seconds in order to allow more time for the engine to spin down to a complete stop after a run and for the DDECs to initialize and be ready for the next operation. Testing indicated that a 12 second interval was adequate, however 15 seconds was selected to allow additional margin.
- C. The following Table summarizes the testing by Hitec with various time delays and the percentages of "Fail to Initialize" signals and "Fail to Run" results on the next start attempt.

<b>365 Main Inc.- Hitec Failure Testing Summary</b>			
Unit No. 1			
Ignition Time Delay	Number of Tests Performed	Improper DDEC Initialization	Fail to Start or Run
Seconds	Tests	Percent	Percent
9	10	60%	30%
11	16	38%	13%
12	20	0%	0%
Unit No. 3			
Ignition Time Delay	Number of Tests Performed	Improper DDEC Initialization	Fail to Start or Run
Seconds	Tests	Percent	Percent
9	10	100%	0%
10	10	100%	0%
11	7	57%	14%
12	10	0%	0%

- D. During the analysis, Hitec also discovered that if the DDECs initialize properly, the DDEC controller energizes a series of 4 pulses. The corrective action by Hitec adds monitoring of these signals by the Hitec QMS PLC. If the initialization process completes and the signals are not received, an indication is registered and the initialization process is repeated.
- E. If the second initialization process still fails, an alarm is reported to the building
- F. engineering staff for corrective action.

## **V EYPMCF COMMENTS AND RECOMMENDATIONS**

- A. During the 15-second engine shut-down and initialization process, the engine is not capable of re-starting should another utility outage occur at that moment. EYPMCF recommends that the Hitec units be staggered in their shut-down sequence so that all units are not unavailable simultaneously. This will mean that there is still UPS power available with an N+1 redundancy while units are in the shut-down sequence and initialized, followed by a return to N+2 redundancy after the process is complete. These redundancy levels apply provided that all units are otherwise operational.
- B. EYPMCF recommends that additional steps be included in the annual equipment preventative maintenance program to specifically document the parameters and corrective action related to these events, such as:
  1. Confirm the engine shut-down time delay in the Hitec QMS PLC
  2. Confirm the supervision of the DDEC 'Initialization Successful' signal by the Hitec QMS PLC including the re-initialization sequence and alarm
  3. Monitor and record the actual spin-down times of each machine and confirm there is adequate time for successful initialization of the DDEC engine controllers
  4. Monitor and record the timing of the staggered engine shut-down sequence

5. Regular performance of the above activities with proper documentation and training will help keep these events and remedies on record for future staff and technicians
- C. EYPMCF recommends that the DDEC engine controllers be checked periodically by facility engineering staff on rounds to verify engines are ready. The 'Initialization Successful' signal is a one-time event on each engine shut-down and would not record any subsequent failure.
- D. The DDEC engine controllers contain extensive information on engine run history and events, however the failure analysis performed by Hitec made no reference to this information. There were comments during interviews that this information was possibly deleted by engine technicians or was not readily accessible to Hitec. Given the critical nature engine performance to the success of the Hitec equipment, EYPMCF recommends that both the Hitec technicians and 365 Main staff be provided with complete software, equipment, and training on the engine and controls. We understand that both the engine manufacturer has changed corporate affiliations and the DDEC controllers, while still supported, are not in common use in new stationary applications on engines of this size.

## **VI CONCLUSIONS**

- A. 365 Main Inc and Hitec have performed an exhaustive forensic evaluation into all possible causes of this equipment failure and, fortunately, were successful in finding the cause and developing a remedy for the condition.
- B. As is often the case, the remedy was a relatively simple one to implement once the problem was discovered and fully understood.
- C. Comprehensive testing of the remedy has not revealed any repeated system or equipment failures and due diligence on the part of 365 Main Inc and Hitec should be exercised so that these events are not forgotten.
- D. 365 Main Inc and Hitec have been very candid and forthcoming to their customers, the industry, and the public regarding this situation and this should be acknowledged.

End of Report