IEC 61508 Functional Safety Assessment

Project:
Honeywell 7800 Series Burner Control System

Customer:
Honeywell Combustion Controls
Golden Valley, MN
USA

Contract No.: Q13/03-070
Report No.: HCC 09/10-38 R002
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Management summary

This report summarizes the results of the functional safety assessment according to IEC 61508 carried out on the:

- ➢ Honeywell 7800 Series Burner Control System

Model S7830 has been assessed to be interference free and may be used in the above system without impacting safety.

The functional safety assessment performed by exida-certification consisted of the following activities:

- *exida* assessed the development process used by Honeywell Combustion Controls by an on-site audit and creation of a safety case against the requirements of IEC 61508.
- *exida* performed a detailed Failure Modes, Effects, and Diagnostic Analysis (FMEDA) of the devices to document the hardware architecture and failure behavior.
- *exida* reviewed field failure data to ensure that the FMEDA analysis was complete.
- *exida* reviewed the manufacturing quality system in use at Honeywell Combustion Controls.

The functional safety assessment was performed to the requirements of IEC 61508: ed2, 2010, SIL 3. A full IEC 61508 Safety Case was prepared, using the *exida* SafetyCaseDB™ tool, and used as the primary audit tool. Hardware process requirements and all associated documentation were reviewed. Environmental test reports were reviewed. Also the user documentation (safety manual) was reviewed.

See section 3 of this document for details on which hardware and software versions have been included in this assessment.

The results of the Functional Safety Assessment can be summarized by the following statements:

The Honeywell 7800 Series Burner Control System **were found to meet the requirements of IEC 61508 for up to SIL 3 (SIL 3 Capable), single use (HFT = 0).**

The manufacturer will be entitled to use the Functional Safety Logo.

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1 Purpose and Scope

This document shall describe the results of the IEC 61508 functional safety assessment of the:

- 7800 Series Burner Control System

by *exida* according to the requirements of IEC 61508: ed2, 2010.

The results of this provides the safety instrumentation engineer with the required failure data as per IEC 61508 / IEC 61511 and confidence that sufficient attention has been given to systematic failures during the development process of the device.

2 Project management

2.1 *exida*

exida is one of the world's leading accredited Certification Bodies and knowledge companies specializing in automation system safety and availability with over 300 years of cumulative experience in functional safety. Founded by several of the world's top reliability and safety experts from assessment organizations and manufacturers, *exida* is a global company with offices around the world. *exida* offers training, coaching, project oriented system consulting services, safety lifecycle engineering tools, detailed product assurance, cyber-security and functional safety certification, and a collection of on-line safety and reliability resources. *exida* maintains a comprehensive failure rate and failure mode database on process equipment.

2.2 Roles of the parties involved

Honeywell Combustion Controls	Manufacturer of the Honeywell 7800 Series Burner Control System.
exida	Performed the hardware assessment
exida	Performed the IEC 61508 Functional Safety Assessment according to option 2 (see section 1)

Honeywell Combustion Controls contracted *exida* to perform the IEC 61508 Functional Safety Assessment of the above mentioned devices.

2.3 Standards / Literature used

The services delivered by *exida* were performed based on the following standards / literature.

[N1]	IEC 61508 (Parts 1 - 7): 2010	Functional Safety of Electrical/Electronic/Programmable Electronic Safety-Related Systems

2.4 Reference documents

2.4.1 Documentation provided by Honeywell Combustion Controls

D01	3.5; 6/1/2009	Dev Process Overview
D02	11/11/2009	NPI Phases and Phase Gate Checklists
D03	8/23/2004	BBC Configuration Management Plan Guidelines
D04	REV. D; 9/1/1998	Engineering Development Proceedure for Engineering Specifications
D05	6/3/2010	Honeywall 7800 Safety Case Database
D08	V1R2; 6/2/2010	Honeywell 7800 Safety Requirements Specification
D14	V0R1; 4/1/2005	Honeywell 7800 Validation Test Specification
D15	Rev 2; 3/3/1992	EC7850 Product FMEA
D16	11/11/2009	Safety Fault Tree 9204xx.pdf
D18	V1R1; 6/2/2010	Honeywell 7800 Series Relay Modules Validation Test Report
D22	V1R0; 6/2/2010	Honeywell 7800 Safety Manual
D23	NA; 3/11/2008	System Architecture Design Checklist
D25	NA; 4/30/2010	Safety Requirements Checklist - Honeywell 7800 Series Relay Modules
D26	6/1/2010	7800 Proven-in-use calculation
D31	11/92; 5/1/1994	EN298 Test Report of the examination of HONEYWELL BURNER CONTROL UNIT, type EC 78xx family
D35	5/27/2010	Fault Injection Test results
D34	11/9/2009	Modification Testing Policy, RM7800 SERIES Modification / Regression Testing
P01	Issue : 1.22; 2/9/2005	PRODUCT REQUIREMENTS SPEC and SOFTWARE DESIGN SPEC RM7800E Enhanced Burner Control Project Number GF32595
P02	1/27/2005	STP (Software Test Plan) to PRD (Product Requirements) Cross Reference
P03	Issue : 1.2; 1/31/2005	Software Test Plan, RM7800E Enhanced Burner Control Project Number GF32595
P04	11/30/2004	7800E RM7890A1056/B1048 State-I/O Chart (sio90.pdf)
P05	V0 R1;	Safety Requirements Document for RM7800
P06	10/21/1991	NGPP (Model 7800) Hardware Block diagram
P07	11/9/2009	NGPP (Model 7800) Safety Analysis - Safety Measures
P08	11/9/2009	7800 Series Safety Relay Concept
P09	1/31/2005	Safety Relay Overview Diagram
P10	10/6/2005	Safety via Interpreter, Measures for Software Integrity
P11	10/7/2005	Top Level Software Flow Diagram
P12	Build Code 4616;	Software Configuration Document (4616)
P13	1/31/2005	Test Results RM7800 Report No. EXM43430 for Dev. No. GF32595
P14	10/21/1991	Safety Audit Checklist for NGPP (Model 7800)
P15	Rev. 5-06;	7800 Fault Codes, S7800A Keyboard Display Module, Product Data
P16	Rev. 8-00;	Engineering Guide (Safety Manual), 7800 SERIES, Programmer Control, A GUIDE SPECIFICATION FOR THE ENGINEER
P17	Rev. 02-02;	Installation Instructions, RM7800E,G,L,M; RM7840E,G,L,M 7800 SERIES Relay Modules
P18	10/7/2005	Process/Document Overview, Introduction to the 7800 SERIES

P19	11/9/2009	Version History, Historical Summary of Model 78xx Software Version Modifications

2.4.2 Documentation generated by *exida*

[R1]	Honeywell Combustion 7800 SafetyCaseDB IEC 61508.esc	Detailed safety case documenting results of assessment (internal document)
[R2]	DRAFT_Q13-03-070 Honeywell R002 V2 R1 IEC 61508 Assessment.docx	IEC 61508 Functional Safety Assessment, Honeywell 7800 Series Burner Control System (This report)
[R3]	HCC 09-10-38 R001 V2R1 Honeywell 7800 FMEDA.doc, July 3, 2013	Failure Modes Effects and Diagnostic Analysis: Honeywell 7800 Series Burner Control System

3 Product Description

The Honeywell 7800 Series Burner Control System is intended for use in a wide range of commercial and industrial combustion control applications including burners, boilers, furnaces, packaged rooftop units, ovens, kilns, and water heaters.

The product should be designed to meet all requirements for SIL 3 according to [N1], so that it can be used as a single product with Hardware Fault Tolerance (HFT) of zero to implement SIL 3 combustion control Safety Integrity Functions (SIF).

The Honeywell 7800 Series Burner Control System is a microprocessor-based integrated burner controller for automatically fired gas, oil, or combination fuel single burner applications. The RM7800/RM7840 Burner controls are used for UL/CSA On/Off, UL/CSA Modulating, and FM/IRI Modulating burner applications. The 7800 series system consists of a Burner control, Dust Cover, Subbase, Amplifier, Purge Card and Optional Keyboard Display Module (standard with RM7800 and RM7838), which includes the following models: EC7810, EC7820, EC7830, EC7840, EC7850, RM7800, RM7838, RM7840, RM7888, RM7890, RM7897, RM7898.

Functions provided by the 7800 Series include automatic burner sequencing, flame supervision, system status indication, system or self-diagnostics and troubleshooting.

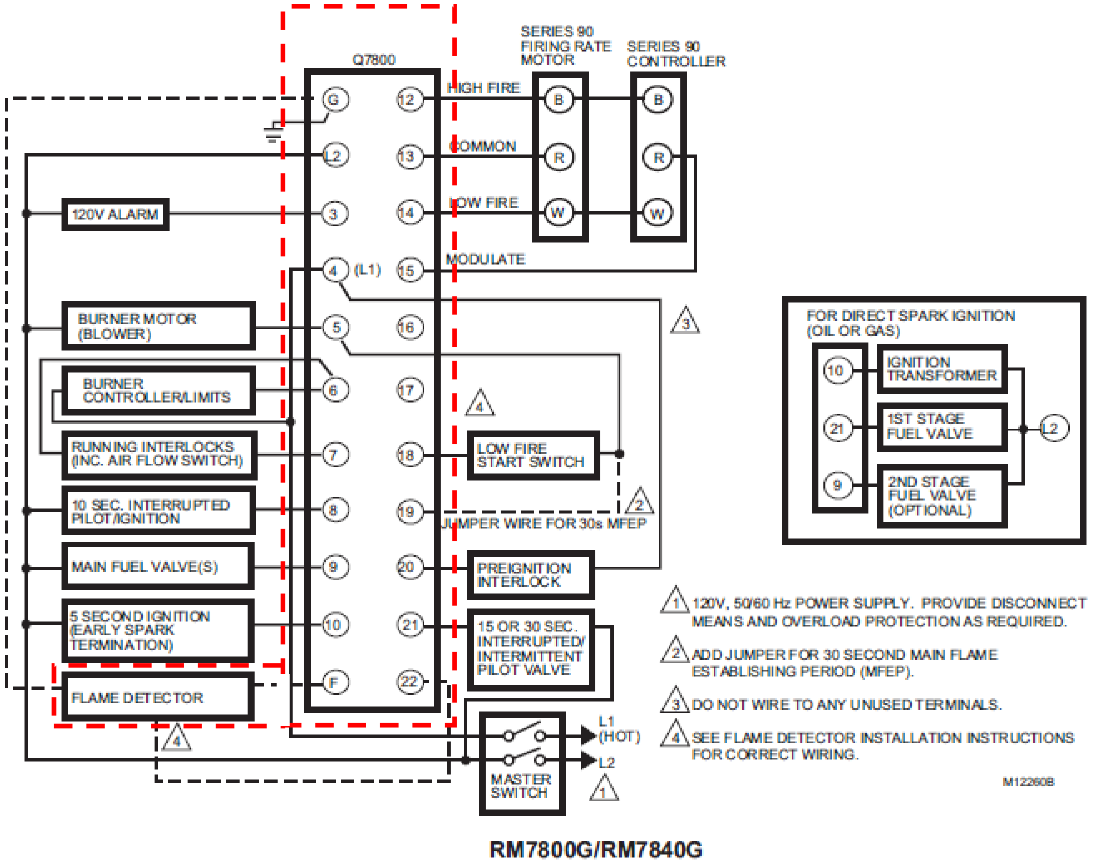
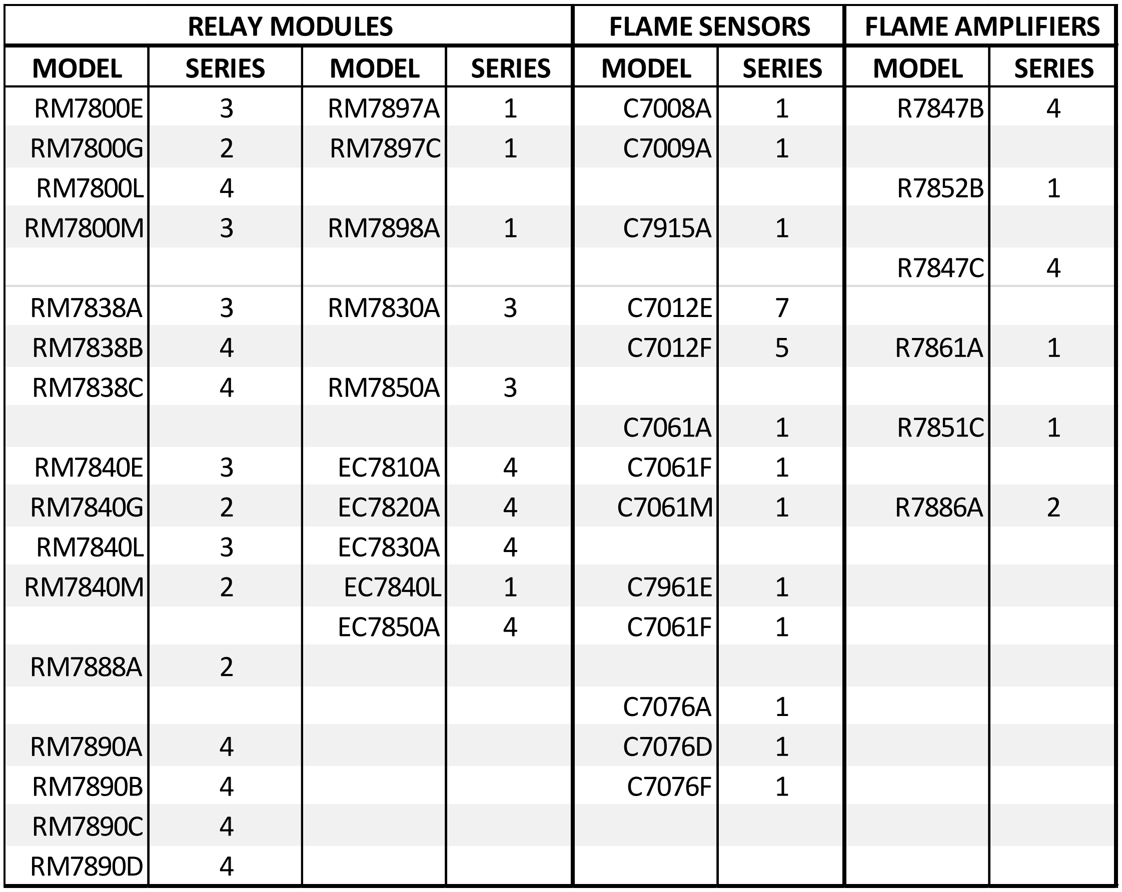

Q7800
SERIES 90 FIRING RATE MOTOR
SERIES 90 CONTROLLER
G
L2
3
4 (L1)
5
6
7
8
9
10
F
12
13
14
15
16
17
18
19
20
21
22
HIGH FIRE
COMMON
LOW FIRE
MODULATE
B
R
W
120V ALARM
BURNER MOTOR (BLOWER)
BURNER CONTROLLER/LIMITS
RUNNING INTERLOCKS (INC. AIR FLOW SWITCH)
10 SEC. INTERRUPTED PILOT/IGNITION
MAIN FUEL VALVE(S)
5 SECOND IGNITION (EARLY SPARK TERMINATION)
FLAME DETECTOR
LOW FIRE START SWITCH
JUMPER WIRE FOR 30s MFEP
PREIGNITION INTERLOCK
15 OR 30 SEC. INTERRUPTED/ INTERMITTENT PILOT VALVE
MASTER SWITCH
L1 (HOT)
L2
FOR DIRECT SPARK IGNITION (OIL OR GAS)
IGNITION TRANSFORMER
1ST STAGE FUEL VALVE
2ND STAGE FUEL VALVE (OPTIONAL)
1 120V, 50/60 Hz POWER SUPPLY. PROVIDE DISCONNECT MEANS AND OVERLOAD PROTECTION AS REQUIRED.
2 ADD JUMPER FOR 30 SECOND MAIN FLAME ESTABLISHING PERIOD (MFEP).
3 DO NOT WIRE TO ANY UNUSED TERMINALS.
4 SEE FLAME DETECTOR INSTALLATION INSTRUCTIONS FOR CORRECT WIRING.
M12260B
RM7800G/RM7840G

Figure 1: Controller and Sensor/Flame Detector, Parts included in the FMEDA

This assessment applies to the following model numbers: EC7810A, EC7820A, EC7830A, EC7840L, EC7850A, RM7800[E,G,L,M], RM7830A, RM7838, RM7840[E,G,L,M], RM7850A, RM7888, RM7890, RM7897A, RM7897C and RM7898A used with one of the following flame detectors and flame amplifiers:

a. C7008A, C7009A Flame Rod sensors with R7847B Flame Amplifier
b. C7915A infra-red sensor with R7852B Flame Amplifier
c. C7012E,F, C7061A,F,M C7961E,F, C7076A,D,F ultra-violet sensors with R7847C, R7861A, R7851C, R7886A Flame Amplifiers

NOTE: You may also view Figure 3.2 for the model and product versions. The product versions are referred to as series numbers below:



RELAY MODULES				FLAME SENSORS		FLAME AMPLIFIERS	
MODEL	SERIES	MODEL	SERIES	MODEL	SERIES	MODEL	SERIES
RM7800E	3	RM7897A	1	C7008A	1	R7847B	4
RM7800G	2	RM7897C	1	C7009A	1		
RM7800L	4					R7852B	1
RM7800M	3	RM7898A	1	C7915A	1		
						R7847C	4
RM7838A	3	RM7830A	3	C7012E	7		
RM7838B	4			C7012F	5	R7861A	1
RM7838C	4	RM7850A	3				
				C7061A	1	R7851C	1
RM7840E	3	EC7810A	4	C7061F	1		
RM7840G	2	EC7820A	4	C7061M	1	R7886A	2
RM7840L	3	EC7830A	4				
RM7840M	2	EC7840L	1	C7961E	1		
		EC7850A	4	C7061F	1		
RM7888A	2						
				C7076A	1		
RM7890A	4			C7076D	1		
RM7890B	4			C7076F	1		
RM7890C	4						
RM7890D	4						

Figure 3.2 7800 Series Burner Control System Model and Series

Model S7830 has been assessed to be interference free and may be used with the above products without impacting safety.

Table 1 gives an overview of the different versions that were considered in the FMEDA of the 7800 Series.

Table 1 Version Overview

RM7800 using Ampli-Check™	RM7800 using Amplifiers with Ampli-Check diagnostics (amplifiers: R7847B, R7852B, R7849B)
RM7800 using Self-Check™	RM7800 using Detectors/Amplifiers with Self-Check diagnostics (C7012E,F; C7061A,F,M;C7961A,F; C7076A,D,F with R7847C, R7861A, R7851C, R7886A)

The RM7800 is classified as a Type B[1] device according to IEC 61508, having a hardware fault tolerance of 0.

[1] Type B element: “Non-Complex” element (using discrete components); for details see 7.4.4.1.3 of IEC 61508-2, ed2, 2010.

4 IEC 61508 Functional Safety Assessment

The IEC 61508 Functional Safety Assessment was performed based on the information received from Honeywell and is documented here.

4.1 Methodology

As part of the IEC 61508 functional safety assessment the following aspects have been reviewed:

- Development process, including:
  - Functional Safety Management, including training and competence recording, FSM planning, and configuration management
  - Specification process, techniques and documentation
  - Validation activities, including development test procedures, test plans and reports, production test procedures and documentation
  - Verification activities and documentation
  - Installation, operation, and maintenance requirements, including user documentation
- Product design
  - Hardware architecture and failure behavior, documented in a FMEDA
- Proven-in-use Criteria
  - Field Warranty Return Data and Shipping Data

4.2 Assessment level

The Honeywell 7800 Series Burner Control System has been assessed per IEC 61508 to Safety Integrity Level 3.

5 Results of the IEC 61508 Functional Safety Assessment

exida assessed the development process used by Honeywell Combustion Controls during the 7800 Series Burner Control System IEC 61508 assessment against the objectives of IEC 61508 parts 1, 2, and 3, see [R01]. In addition, *exida* assessed the field warranty return data and shipping history of the product to verify that the proven-in-use requirements have been met. The proven in use evidence was then used as justification for IEC 61508 requirements related to the avoidance and control of systematic failures. A Safety Case was created for the 7800 Series Burner Control System thereby documenting how this product meets all of the requirements from IEC 61508. This safety case is summarized in this report.

5.1 Lifecycle Activities and Fault Avoidance Measures

The 7800 Series Burner Control was not developed with a process that is fully compliant with IEC 61508. However, all of the requirements of IEC 61508 have been satisfied either by proven-in-use, by a part of the development process that is compliant, or by supplemental development work that was done in order to bring the product up to compliance. This section will summarize at a high level how each of the requirements has been satisfied.

The result of the assessment can be summarized by the following observations:

All of the requirements of IEC 61508 SIL 3 have been satisfied either by the development process used to originally develop the 7800 Series Burner Control System**, the proven-in-use evidence, or supplemental development work that was done in order to bring the product to compliance.**

5.1.1 Functional Safety Management

FSM Planning

Development projects are managed according to a standard development process consisting of Tasks that belong to 1 of 6 Phases. There are Gate assessments at the end of each phase which verify that all required tasks of that phase have been successfully completed before it is ok to proceed to the next phase. Tasks are further detailed with who is responsible for the task.

Version Control

All documents, including design drawings are under version control as defined in [D03]. SourceSafe is used as the version control system.

Training, Competency recording

This requirement is met by the proven-in-use evidence.

5.1.2 Safety Requirements Specification and Architecture Design

A safety requirements specification was created for the 7800 Series Burner Control System after the product had been in the field for many years (see [D08]). This document was created as part of the effort to bring the product into compliance with IEC 61508. As part of the assessment, the specification was reviewed by an independent third party, and the safety requirements checklist was filled out as part of the review.

Items from **IEC 61508-2, Table B.1** include project management, documentation, separation of safety requirements from non-safety requirements, structured specification, inspection of the specification, semi-formal methods and checklists.

5.1.3 Hardware Design

The requirements in the area of the hardware design process are satisfied by proven-in-use.

5.1.4 Software Design

The requirements in the area of the software design process are satisfied by proven-in-use.

5.1.5 Validation

All safety requirements were validated by an independent third party test that was done as part of the assessment. Most requirements were validated by dynamic analysis; some requirements were validated by static analysis. The validation test report includes a table showing how all safety requirements have been validated. The results of the validation testing have been documented and reviewed as part of the assessment. In addition, the proven-in-use analysis supports the validation requirements.

Items from IEC **61508-2, Table B.5** included functional testing and functional testing under environmental conditions, fault insertion testing, project management, documentation, failure analysis, and field experience. This meets SIL 3.

5.1.6 Verification

The verification requirements are satisfied by the proven-in-use evidence.

5.1.7 Modifications

The modification process was not analyzed as part of this assessment. As a result, the assessment is limited to the current version of the product as defined in section 3 of this document.

5.1.8 User documentation

A safety manual has been created for the 7800 Series Burner Control System. This safety manual was assessed by *exida*. The final version is considered to be in compliance with the requirements of IEC 61508. The document includes all required reliability data and operations, maintenance, and proof test procedures.

Items from IEC **61508-2, Table B.4** include operation and maintenance instructions, user friendliness, maintenance friendliness, project management, documentation, limited operation possibilities, protection against operator mistakes and operation only by skilled operators. This meets SIL 3.

5.2 Proven-in-use analysis

The functional safety standard IEC 61508 has specific requirements with regard to Proven In Use considerations for existing products. These requirements are listed in both IEC 61508-2 and IEC 61508-3. This proven in use assessment is being done as part of a complete assessment of the 7800 Series Burner Control System.

The relevant requirements and their reference are listed in this section. For each requirement an argument is provided why the 7800 Series Burner Control System meets this requirement.

5.2.1 IEC 61508 Proven In Use requirements

5.2.1.1 IEC 61508-2 Clause 7.4.7.6

"A previously developed subsystem shall only be regarded as proven in use when it has a clearly restricted functionality and when there is adequate documentary evidence which is based on the previous use of a specific configuration of the subsystem (during which time all failures have been formally recorded, see 7.4.7.10), and which takes into account any additional analysis or testing, as required (see 7.4.7.8). The documentary evidence shall demonstrate that the likelihood of any failure of the subsystem (due to random hardware and systematic faults) in the E/E/PE safety-related system is low enough so that the required safety integrity level(s) of the safety function(s) which use the subsystem is achieved."

For a device to be considered proven-in-use the volume of operating experience needs to be considered. For the 7800 Series Burner Control System, this information is obtained from the sales data which is documented in [D26].

The product and has been on the market for over 15 years.

For this assessment, operating experience and field failure rates were only considered for units that shipped from 2005 through 2009. Units that were shipped after that date were not counted because of the uncertainty of whether they have been installed, yet. The sales data [D26] indicates that the total number of shipped units during this time period is over 50,000. For failure rates calculated on the basis of field returns only the hours recorded during the warranty period of the manufacturer are used by exida, since this is the only time frame when failures can be expected to be reported. It must be assumed that all failures after the warranty period are not reported to the manufacturer.

Honeywell offers a 12 month warranty period; this period starts on the date of installation. Volume of operating experience must be based on installation dates and not on shipment dates. Since installation dates are not available, it is assumed that the relays are installed 6 months after shipment. From these assumptions, the number of operational hours is estimated to be 410,143,608.

These operating hours are considered to be sufficient taking into account the medium complexity of the sub-system and the use in SIL 3 safety functions.

The warranty database case history [D26] indicates that 282 failures were found during this period.

There is no evidence that all devices are returned when a failure occurs within the warranty period. Therefore it is to be assumed that only 70% of failures are returned. This leads to the following number of estimated failures for the 7800:

Estimated failures = 282 / 0.7 = 403 failures

From this information, an overall failure rate for the 7800 Series Burner Control System can be calculated. The failure rate point estimate yields 9.82E-07 [1/hr]. IEC 61508 requires the calculation of a 70% upper confidence limit for the failure rate. Given the data above the 70% upper confidence limit for the failure rate equals 1.01E-06 [1/hr].

This information must be compared to the information obtained from a Failure Modes, Effects and Diagnostic Analysis of the product. The failure rates calculated from the field data must be less than the failure rates obtained from the FMEDA. If the field failure rate is larger this is an indication of serious systematic design issues.

The FMEDA shows that the 7800 Series Burner Control System has an expected failure rate of 1.07E-06 [1/hr]. Therefore, the actual failure rate is less than the failure predicted by the FMEDA, which shows that there is not a significant number of systematic design issues.

5.2.2 IEC 61508-2 Clause 7.4.7.7

"The documentary evidence required by 7.4.7.6 shall demonstrate that the previous conditions of use (see note) of the specific subsystem are the same as, or sufficiently close to, those which will be experienced by the subsystem in the E/E/PE safety-related system, in order to determine that the likelihood of any unrevealed systematic faults is low enough so that the required safety integrity level(s) of the safety function(s) which use the subsystem is achieved.

NOTE The conditions of use (operational profile) include all the factors which may influence the likelihood of systematic faults in the hardware and software of the subsystem. For example, environment, modes of use, functions performed, configuration, interfaces to other systems, operating system, translator, human factors."

The 7800 Series Burner Control System is a device with a very specific function which is control all functions of a burner system. Therefore, the device will be used in a similar manner as it was previously used. In addition, this device is used in industrial environments, so the operating conditions encountered are likely to be similar. Consequently, as the conditions of use are considered identical or sufficiently close, this requirement is met.

5.2.3 IEC 61508-2 Clause 7.4.7.8

"When there is any difference between the previous conditions of use and those which will be experienced in the E/E/PE safety-related system, then any such difference(s) shall be identified and there shall be an explicit demonstration, using a combination of appropriate analytical methods and testing, in order to determine that the likelihood of any unrevealed systematic faults is low enough so that the required safety integrity level(s) of the safety function(s) which use the subsystem is achieved."

As stated in section 5.2.2 the previous conditions of use for the 7800 Series Burner Control System and the expected conditions of use are considered to be identical or sufficiently close. Therefore this requirement is met.

5.2.4 IEC 61508-2 Clause 7.4.7.9

"The documentary evidence required by 7.4.7.6 shall establish that the extent of previous use of the specific configuration of the subsystem (in terms of operational hours), is sufficient to support the claimed rates of failure on a statistical basis. As a minimum, sufficient operational time is required to establish the claimed failure rate data to a single-sided lower confidence limit of at least 70 % (see IEC 61508-7, annex D and IEEE 352). An operational time of any individual subsystem of less than one year shall not be considered as part of the total operational time in the statistical analysis (see note).

NOTE The necessary time, in terms of operational hours, required to establish the claimed rates of failure may result from the operation of a number of identical subsystems, provided that failures from all the subsystems have been effectively detected and reported (see 7.4.7.10). If, for example, 100 subsystems each work fault-free for 10,000 h, then the total time of fault-free operation may be considered as 1,000,000 h. In this case, each subsystem has been in use for over a year and the operation therefore counts towards the total number of operational hours considered."

For a failure rate the lower confidence limit that the standard refers to is not conservative, so exida uses an upper confidence limit.

The calculated operational hours for the 7800 Series Burner Control System are 410,143,608. These operating hours are considered to be sufficient taking into account the medium complexity of the sub-system and the use in safety functions up to SIL 3. A single sided upper confidence limit of 70% is calculated for the failure rate derived from the field failure data of the 7800 Series Burner Control System. As a result this requirement is met.

5.2.5 IEC 61508-2 Clause 7.4.7.10

"Only previous operation where all failures of the subsystem have been effectively detected and reported (for example, when failure data has been collected in accordance with the recommendations of IEC 60300-3-2) shall be taken into account when determining whether the above requirements (7.4.7.6 to 7.4.7.9) have been met."

Assuming 100% failure reporting is unrealistic irrespective of the failure data reporting and collection methods utilized. Consequently in the Proven In Use failure rate calculation it is assumed that only a percentage of the actual failures is reported during the warranty period. This percentage is 70%. Based on this assumption it is argued that this requirement is met.

5.2.6 IEC 61508-2 Clause 7.4.7.11

"The following factors shall be taken into account when determining whether or not the above requirements (7.4.7.6 to 7.4.7.9) have been met, in terms of both the coverage and degree of detail of the available information (see also 4.1 of IEC 61508-1):

a) the complexity of the subsystem;

b) the contribution made by the subsystem to the risk reduction;

c) the consequence associated with a failure of the subsystem;

d) the novelty of design."

Each of the factors listed in this clause have been considered in the above requirements. The design is not considered to be overly complex compared to other similar products. In addition, the design was created almost 20 years ago, so the design cannot be considered novel , but rather it is a proven device, similarly designed to other comparable products. The consequence associated with failure of this subsystem is application dependent and therefore is not known at this time. The contribution by this device to the risk reduction will be relatively small since it is only one part of the safety related system, and since good standard practice involves creating other layers of protection as well. Consequently this requirement has been met.

5.2.7 IEC 61508-2 Clause 7.4.7.12

“The application of a "proven-in-use" safety-related subsystem in the E/E/PE safety related system should be restricted to those functions and interfaces of the subsystem which meet the relevant requirements (see 7.4.7.6 to 7.4.7.10).

NOTE The measures 7.4.7.4 to 7.4.7.12 are also applicable for subsystems which contain software. In this case it has to be assured that the subsystem performs in its safety related application only that function for which evidence of the required safety integrity is given. See also 7.4.2.11 of IEC 61508-3.”

The 7800 Series Burner Control System has a limited set of safety functions which apply to all installations. These functions meet the requirements of 7.4.7.6 to 7.4.7.10 as stated above. Consequently this requirement is met.

5.3 Hardware Assessment

To evaluate the hardware design of the Honeywell 7800 Series Burner Control System, a Failure Modes, Effects, and Diagnostic Analysis was performed. This is documented in [R3]. The FMEDA was verified using Fault Injection Testing as part of the assessment (see [D35]).

A Failure Modes and Effects Analysis (FMEA) is a systematic way to identify and evaluate the effects of different component failure modes, to determine what could eliminate or reduce the chance of failure, and to document the system in consideration. An FMEDA (Failure Mode Effect and Diagnostic Analysis) is an FMEA extension. It combines standard FMEA techniques with extension to identify online diagnostics techniques and the failure modes relevant to safety instrumented system design.

From the FMEDA failure rates are derived for each important failure category. Table 1 lists these failure rates as reported in the FMEDA reports. The failure rates are valid for the useful life of the devices, which are defined as in the FMEDA report [R3] as approximately 10 years. This information is listed in the Safety Manual, see [D22].

Table 1: Failure rates for Simplex Safety PLC according to IEC 61508

(*Note that the SD and SU category includes failures that do not cause a spurious trip)

Device	λ_{SD}	λ_{SU}[2]	λ_{DD}	λ_{DU}	**SFF**
RM7800 using Amplifiers with Ampli-Check diagnostics	830 FIT	146 FIT	0 FIT	7 FIT	99.3%
RM7800 using Detectors/Amplifiers with Self-Check diagnostics	967 FIT	146 FIT	0 FIT	8 FIT	99.3%

These results must be considered in combination with PFD_{AVG} or PFH values of other devices of a Safety Instrumented Function (SIF) in order to determine suitability for a specific Safety Integrity Level (SIL). The Safety Manual states that the application engineer should calculate the PFD_{AVG} or PFH for each defined safety instrumented function (SIF) to verify the design of that SIF.

The architectural constraints requirements of IEC 61508-2, Table 2 are also reviewed. The 7800 Series Burner Control System is classified as a Type B device according to IEC 61508, having a hardware fault tolerance of 0. The analysis shows that the system has a safe failure fraction > 99% and therefore per even worst case assumptions, the non-redundant unit may be used up to SIL

3 based on architecture constraints.

The analysis shows that design of The Honeywell 7800 Series Burner Control System **meets the hardware requirements of IEC 61508 SIL 3 when used as a single element (HFT = 0).**

[2] It is important to realize that the No Effect failures are no longer included in the Safe Undetected failure category according to IEC 61508, ed2, 2010.

6 Terms and Definitions

DET	De-energize to trip
ET	Energize to trip
Fault tolerance	Ability of a functional unit to continue to perform a required function in the presence of faults or errors (IEC 61508-4, 3.6.3)
FIT	Failure In Time (1x10^{-9} failures per hour)
FMEDA	Failure Mode Effect and Diagnostic Analysis
HFT	Hardware Fault Tolerance
Low demand mode	Mode, where the frequency of demands for operation made on a safety-related system is no greater than twice the proof test frequency.
PFD_{AVG}	Average Probability of Failure on Demand
SFF	Safe Failure Fraction summarizes the fraction of failures, which lead to a safe state and the fraction of failures which will be detected by diagnostic measures and lead to a defined safety action.
SIF	Safety Instrumented Function
SIL	Safety Integrity Level
SIS	Safety Instrumented System – Implementation of one or more Safety Instrumented Functions. A SIS is composed of any combination of sensor(s), logic solver(s), and final element(s).
Type A element	“Non-Complex” element (using discrete components); for details see 7.4.4.1.2 of IEC 61508-2
Type B element	“Complex” element (using complex components such as micro controllers or programmable logic); for details see 7.4.4.1.3 of IEC 61508-2

7 Status of the document

7.1 Liability

exida prepares reports based on methods advocated in International standards. Failure rates are obtained from a collection of industrial databases. *exida* accepts no liability whatsoever for the use of these numbers or for the correctness of the standards on which the general calculation methods are based.

7.2 Releases

Version:	V2	
Revision:	R1	
Version History:	V2, R1:	Updated to 2010 standard; included 4 new models: C7061M, C7076F, RM7888A1019, and RM7888A1927 and analyzed the S7830; TES July 3, 2013
	V1, R2:	Updated version number table, R. Chalupa, March 4, 2011
	V1, R1:	Expanded model list, R. Chalupa, February 28, 2011
	V1, R0:	Added product version numbers; Updated FMEDA and PIU Data; Updated Document Versions/Dates; June 3rd, 2010
	V0, R2:	Reviewed Draft, May 29th, 2010
	V0, R1:	Draft; May 28th, 2010
Authors:	Michael Medoff	
Review:	V0, R1: Dr. William Goble;	
Release status:	Released	

7.3 Future Enhancements

At request of client.

7.4 Release Signatures

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