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Westinghouse Astronuclear Laboratory

WANL R-202 PRESENTATION

AT

SPACE NUCLEAR PROPULSION OFFICE,
CLEVELAND EXTENSION,

NASA,

JULY 16, 1970.

MASTER

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WANL R-202 PRESENTATION

OUTLINE

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 - SCOPE OF SYSTEM FMECA.
 - PROGRESS OF FMECA ACTIVITY.
 - PROBLEM AREAS.
 - EXAMPLE OF COMPONENT FMECA - CONTROL DRUM DRIVE ASSEMBLY.
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- OBJECTIVES OF RELIABILITY MODELING AND LOGIC DIAGRAM ACTIVITY.
 - ASSUMPTIONS.
 - PROGRESS OF MODELING/LOGIC DIAGRAM ACTIVITY.

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OBJECTIVES OF SYSTEM FMECA

- THE FMECA WILL BE AN INTEGRAL PART OF THE SUBSYSTEM/COMPONENT DESIGN PROCESS.
- THE FMECA WILL PROVIDE FOR SYSTEMATIC ANALYSIS OF ALL SYSTEM EFFECTS RESULTING FROM FAILURE OF COMPONENTS TO PERFORM THEIR SPECIFIED FUNCTIONS.
- THE FMECA WILL PROVIDE A MULTI-DISCIPLINARY BASIS FOR:
 - CONTINGENCY ANALYSIS.
 - SINGLE FAILURE POINT IDENTIFICATION.
 - RELIABILITY/SAFETY MATH MODELS.
 - MAINTAINABILITY STUDIES.
 - ESTABLISHING MALFUNCTION RECOVERY AND EMERGENCY MODE CONTROL REQUIREMENTS.
 - ESTABLISH INSTRUMENTATION REQUIREMENTS.
 - MALFUNCTION ANALYSIS STUDIES.
 - TREND DATA IDENTIFICATION.
- THE FMECA WILL USE THE ASSUMPTION OF SINGLE FAILURES INITIALLY BUT WILL CONSIDER MULTIPLE FAILURES AS REQUIRED TO OPTIMIZE THE SYSTEM FAILURE-ADAPTIVE CAPABILITY AND MAXIMIZE SYSTEM RELIABILITY.

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SCOPE OF SYSTEM FMECA

THE WANL SYSTEM FMECA WILL DEAL WITH TWO (2) ENGINE SUBSYSTEMS.

● STRUCTURAL SUPPORT COOLANT ASSEMBLY (SSCA)

THE SSCA FMECA WILL INCLUDE THE FOLLOWING COMPONENTS:

- STRUCTURAL SUPPORT COOLANT VALVE (SSCV).
- STRUCTURAL SUPPORT BLOCK VALVE AND ACTUATOR (SSBV).
- STRUCTURAL SUPPORT COOLANT LINES (SCL) (PROVIDED BY ANSC).

● NUCLEAR SUBSYSTEM (NSS)

THE NSS FMECA WILL INCLUDE THE FOLLOWING COMPONENTS:

- CONTROL DRUM DRIVE ASSEMBLY.
- REFLECTOR ASSEMBLY.
- INTERNAL SHIELD.
- SUPPORT PLATE AND PLENA.
- CORE PERIPHERY.
- CLUSTER HARDWARE.
- FUEL ELEMENTS.

- A TABLE OF CONTENTS OF THE WANL SYSTEM FMECA IS INCLUDED IN APPENDIX I.

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PROGRESS OF WANL SYSTEM FMECA ACTIVITY

<u>FMECA'S REQ'D. BY IED NO. 485</u>	<u>FMECA'S COMPLETED</u>	<u>FMECA'S OVER 50% COMPLETE</u>	<u>FMECA'S IN INITIAL STAGES</u>
1. SSCA		X	
2. CDDA	X		
3. FUEL			X
4. CLUSTER HARDWARE			X
5. REFLECTOR ASSEMBLY		X	
6. INTERNAL SHIELD		X	
7. CORE PERIPHERY			X
8. SUPPORT PLATE AND PLENA	X		

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PROBLEM AREAS

- EARLY IN THE SECOND QUARTER OF 1970, WANL SUBMITTED TO ANSC A COMPLETE SYSTEM FMECA.
- EFFECTIVE 25 MAY 1970, A NEW SYSTEM FMECA PROCEDURE (R-101-300) WAS ISSUED BY ANSC.
- THE MORE EXTENSIVE OBJECTIVES OF THE NEW PROCEDURE REQUIRES A SUBSTANTIAL MODIFICATION OF THE EXISTING WANL SYSTEM FMECA AND SERIOUSLY RAISES THE QUESTION OF THE MATURITY THAT CAN BE EXPECTED OF THE WANL SYSTEM FMECA IN SUPPORT OF ENGINE - PDR.

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OBJECTIVES OF RELIABILITY MODELING AND LOGIC.
DIAGRAM ACTIVITY

- PROVIDE A MATHEMATICAL BASIS FOR THE IDENTIFICATION OF ALL SUBSYSTEM/COMPONENT FAILURE STATES AND AN ESTIMATE OF THEIR PROBABILITY WHICH WILL PERMIT THE SCHEDULED MISSION TO BE SUCCESSFULLY COMPLETED
- PROVIDE A BASIS FOR DEVELOPING AND UPDATING COMPUTER PROGRAMS OF RELIABILITY MATH MODELS
- PROVIDE A BASIS FOR RELIABILITY ANALYSIS USING MONTE CARLO AND PROPAGATION OF ERROR TECHNIQUES
- PROVIDE A BASIS FOR MAINTAINABILITY STUDIES
- PROVIDE A BASIS FOR DEVELOPING AND MAINTAINING THE NSS COMMON RELIABILITY ANALYSIS MODEL (CRAM) WHICH SHALL BE COMPATIBLE WITH AND A PART OF THE OVERALL ENGINE MODEL

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ASSUMPTIONS

- THE NERVA ENGINE SYSTEM IS COMPOSED OF NINE (9) INDEPENDENT SUBSYSTEMS
- THE WANL-CRAM SHALL CONSIST OF TWO (2) OF THESE SUBSYSTEMS, E.G., NSS AND SSCA
- THE ENGINE DESIGN CONCEPT UTILIZED WILL BE THE SO-CALLED S-3 CONCEPT
- ALL THRUST CYCLES ARE ASSUMED TO BE IDENTICAL (60 - 10 MINUTE BURNS)
- THE BREAKDOWN OF OPERATIONAL PHASES FOR EACH IDENTICAL CYCLE WILL BE AS SHOWN IN FIGURE 1
- ALL SUBSYSTEMS AND COMPONENTS HAVE A CONSTANT FAILURE RATE
- THE REFERENCE TIME LINE OF SYSTEM VALVE ACTIONS WILL BE AS SHOWN IN FIGURE 2
- MODE B MAINTAINABILITY CONCEPT WILL BE USED (LOSS OF REDUNDANT PARTS ALLOWABLE DURING 10 HOUR LIFE TO MEET 0.995)

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REFERENCE RELIABILITY (RR) MISSION CYCLE

FIGURE 1

FIG. 2 THRUST PHASE VALVE POSITION CHART

PROGRESS OF WANL RELIABILITY MODELING AND LOGIC
DIAGRAM ACTIVITY

<u>MODELS/DIAGRAMS REQUIRED</u>	<u>MODELS/DIAGRAMS COMPLETED</u>	<u>MODELS/DIAGRAMS OVER 50% COMPLETE</u>	<u>MODELS/DIAGRAMS IN INITIAL STAGES</u>
1. SSCA	X		
2. CDDA	X		
3. FUEL			X
4. CLUSTER HARDWARE			X
5. REFLECTOR ASSEMBLY		X	
6. INTERNAL SHIELD		X	
7. CORE PERIPHERY			X
8. SUPPORT PLATE AND PLENA		X	

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WANL SYSTEM FMECA
TABLE OF CONTENTS

- I. Comments to "Scope"
- II. Comments to "Summary"
- III. Analysis
 - A. General
 - 1. Comments to "Engine Operating Phases"
 - 2. Comments to "Engine Breakdown"
 - 3. Comments to "Analysis Format"
 - 4. Comments to "Ground Rules and Assumptions"
 - H. Structural Support Coolant Assembly (SSCA)
 - 1.0 Description
 - 2.0 Function During Operational Phases
 - 2.1 Normal Thrusting Mode
 - 2.2 Cooldown Mode
 - 2.3 SSCA Malfunction Mode
 - 3.0 Component FMECA's
 - 3.1 Structural Support Coolant Valve (SSCV)
 - 3.1.1 Description
 - 3.1.2 Function During Operational Phases
 - 3.1.3 SSCV Failure Modes
 - 3.1.4 Significant SSCV Design/System Problems
 - 3.1.5 System FMECA Work/Action Sheets
 - 3.1.6 System FMECA Summary Sheet

3.2 Structural Support Block Valve and Actuator (SSBV)

- 3.2.1 Description
- 3.2.2 Function During Operational Phases
- 3.2.3 SSBV Failure Modes
- 3.2.4 Significant SSBV Design/System Problems
- 3.2.5 System FMECA Work/Action Sheets
- 3.2.6 System FMECA Summary Sheet

3.3 Structural Support Coolant Lines (SCL)

- 3.3.1 Description
- 3.3.2 Function During Operational Phases
- 3.3.3 SCL Failure Modes
- 3.3.4 Significant SCL Design/System Problems
- 3.3.5 System FMECA Work/Action Sheets
- 3.3.6 System FMECA Summary Sheet

I. Nuclear Subsystem (NSS)

1.0 Description

2.0 Function During Operational Phases

- 2.1 Normal Thrusting Mode
- 2.2 Electrical Power Distribution and Regulation
- 2.3 Nuclear Radiation Shielding
- 2.4 Emergency Operating Mode
- 2.5 Propellant Feed System Malfunction Mode
- 2.6 SSCA Malfunction Mode

3.0 Component FMECA's

3.1 Control-Drum Drive Assembly (CDDA)

- 3.1.1 Description
- 3.1.2 Function During Operational Phases
- 3.1.3 CDDA Failure Modes
- 3.1.4 Significant CDDA Design/System Problems
- 3.1.5 System FMECA Work/Action Sheets
- 3.1.6 System FMECA Summary Sheet

3.2 Reflector Assembly (RA)

- 3.2.1 Description
- 3.2.2 Function During Operational Phases
- 3.2.3 RA Failure Modes
- 3.2.4 Significant RA Design/System Problems
- 3.2.5 System FMECA Work/Action Sheets
- 3.2.6 System FMECA Summary Sheet

3.3 Internal Shield (SI)

- 3.3.1 Description
- 3.3.2 Function During Operational Phases
- 3.3.3 SI Failure Modes
- 3.2.4 Significant SI Design/System Problems
- 3.2.5 System FMECA Work/Action Sheets
- 3.2.6 System FMECA Summary Sheet

3.4 Support Plate and Plena (PS)

- 3.4.1 Description
- 3.4.2 Function During Operational Phases
- 3.4.3 PS Failure Modes
- 3.4.4 Significant PS Design/System Problems
- 3.4.5 System FMECA Work/Action Sheets
- 3.4.6 System FMECA Summary Sheet

3.5 Core Periphery (CP)

- 3.5.1 Description
- 3.5.2 Function During Operational Phases
- 3.5.3 CP Failure Modes
- 3.5.4 Significant CP Design/System Problems
- 3.5.5 System FMECA Work/Action Sheets
- 3.5.6 System FMECA Summary Sheet

3.6 Cluster Hardware (CH)

- 3.6.1 Description
- 3.6.2 Function During Operational Phases
- 3.6.3 CH Failure Modes
- 3.6.4 Significant CH Design/System Problems
- 3.6.5 System FMECA Work/Action Sheets
- 3.6.6 System FMECA Summary Sheet

3.7 Fuel Elements (FE).

- 3.7.1 Description**
- 3.7.2 Function During Operational Phases**
- 3.7.3 FE Failure Modes**
- 3.7.4 Significant FE Design/System Problems**
- 3.7.5 System FMECA Work/Action Sheets**
- 3.7.6 System FMECA Summary Sheet**