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14. ABSTRACT

This report describes a best practice for writing procedures for test operations of solid motors and liquid engines based on two decades worth of test experience. The Air Force Research Laboratory, at Edwards AFB CA, recently completed an effort to create procedure writing guidance for test operations. This procedure writing guidance is designed as an aid for new employees and a reference document for those with test experience. The guidance was created with input from 20 people with a wide variety of test experience covering the entire range of tests of solid motors and liquid engines both at sea level and altitude. The group included representatives from the quality assurance and safety offices.

This paper will concentrate on the procedure writing rules of thumb and procedure modification process established by the guidelines as these ideas have universal applicability and are derived from lessons learned. The specific procedure boilerplate requirements and template will not be discussed in this paper.

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PROCEDURE WRITING AID

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ABSTRACT

This report describes a best practice for writing procedures for test operations of solid motors and liquid engines based on two decades worth of test experience. The Air Force Research Laboratory, at Edwards AFB CA, recently completed an effort to create procedure writing guidance for test operations. This procedure writing guidance is designed as an aid for new employees and a reference document for those with test experience. The guidance was created with input from 20 people with a wide variety of test experience covering the entire range of tests of solid motors and liquid engines both at sea level and altitude. The group included representatives from the quality assurance and safety offices.

This paper will concentrate on the procedure writing rules of thumb and procedure modification process established by the guidelines as these ideas have universal applicability and are derived from lessons learned. The specific procedure boilerplate requirements and template will not be discussed in this paper.

INTRODUCTION

The Air Force Research Laboratory (AFRL) recently established procedure writing guidance for test operation. The purpose of this guidance is to provide a common base for the creation of test procedures at AFRL. Procedure writing rules of thumb were created based on previous procedure writing guidance, most in draft form and never published, and from lessons learned. The guidance was designed as a training aid for new employees and a reference document for those with test experience.

A significant portion of the guidance was dedicated to the procedure modification process due to concerns that had been expressed by the AFRL Safety Office about the different interpretations and implementation of regulation requirements for procedure modification. The regulation requirements are very generic and for the most part just state who must approve procedure modification, but include nothing specific about how these changes are to be documented.

PROCEDURE WRITING RULES OF THUMB

Procedure steps should explain what needs to be done in a succinct and clear manner. As a general rule, steps should only contain one action when possible. Page breaks should not occur in the middle of paragraphs or steps to ensure continuity and readability for the test team. Keep wording of steps consistent. For example don't use "turn HLV fully counterclockwise" in one step, "fully back off HLV" in another, and "decrease fully HLV" in another. Pick one way of stating things and stick with it.

Know how procedures link with other procedures. Some procedures can be completed at the same time without causing a problem, while others have to be performed in series. Procedures that are done in series should have a step to verify the prerequisite procedure is complete before continuing. Procedures or their prerequisite procedures should first establish a starting state for the system. This initial system configuration is determined by verifying that all systems are in a known condition at the beginning of the operation. Not verifying the starting state of the system has resulted in propellant flowing or not flowing as expected during operation. This is inconvenient at best and could jeopardize the safety of the operation in the worst case.

Remote valves should be cycled, if safe to do so, early in an operation to verify they are working properly. This cycling should be done the day of the operation if possible. Valves that worked the previous day have been found to not be working the following day. A small engine test failed due to mud daubers nesting in a quarter inch line between tests preventing pressure from being relieved from the line.

When writing the procedures keep the crew in mind. At times there will be steps where the order does not matter from an operations standpoint. Always arrange these steps in a logical order based on physical location to prevent unnecessary crew movement. Include quick reference information for the crew to make the procedure easier to follow. For example, just before a series of steps that are performed at the T-Room, place the phrase **(T-room)** i.e.

(T-room)
4.12 RC Verify XXXX.

Consider the operations day flow when writing procedures. Operations that do not require a Test Conductor (TC) to actively follow the steps, but just verify they have been completed, should be done in separate checklists. In these separate checklists it should be noted who can run the list (e.g. Red Crew Leader, Instrumentation Crew, Test Panel Operator, etc). This organization allows simultaneous operations and can save several hours during pre-test setup and post-test shutdown. Procedures should be written so that the TC can properly document step completion. Providing checkmark spaces located along one side of the page allows consistent documentation of completed steps. Mixing locations for the checking has caused steps to be missed and for incidents to occur.

Procedure reviews can be facilitated by including information that helps the reviewers or by making the procedure such that they don't require extra reviews. Only make facility procedures specific to a program if the procedure is truly program specific. If a facility procedure is not made generic, then the next program will have to revise the procedure and get it approved instead of just adopting the existing procedure.

When the push of one button results in a sequence of actions being performed it is a good idea to add a reference to the actions performed in the procedure. This can be done in a note or by indenting and listing each as if it was a step but with no actionee or space for a checkmark or with CC in front of the actions to indicate computer controlled. This inclusion does not impact operations but often speeds up procedure reviews. For example

TPO **Press** sequence start button.

T-20	Sequence start
T-12	**OPEN** ROV 5-004
	OPEN ROV 5-006
	OPEN ROV 5-007
T-10	**OPEN** ROV 5-008
	OPEN ROV 5-009
	OPEN ROV 5-012
T-2	**Start** Film Cameras
T-0	**Start** Igniter A signal
T+2	**Stop** Igniter A signal

When references include units, stay consistent as to metric or English units. Additionally, parenthetical equivalence should not be used as they have caused confusion in the past resulting in program failures.

PROCEDURE MODIFICATION PROCESS

Procedures are maintained in the configuration management office. The official copy of a procedure is one from configuration management and annotated with configuration management tracking number. Configuration management is important to maintain traceability of all procedures to a

known system operation and state. Traceability is paramount as procedures are modified for different test programs in the test areas. Configuration management is mandatory for ensuring old and obsolete procedures are not used and mixed with newer procedures as systems mature and procedures are modified.

Deviations to approval procedures are called redlines at AFRL. The redline approval process is describe in AFRL/RZ-West Operating Instruction 61-103, but this instruction gives no guidance about how to document the redline changes other than that they should be annotated in red ink on the procedure. Without specific instructions redline changes were being documented multiple different ways and the AFRL Safety Office requested guidance to be created to standardize the process. Redline changes can be permanent, one-time or temporary, or changes made during the operations. These changes can be either typed or handwritten.

The following three criteria were used to create the documenting processes for procedure modifications.

1. It is clear that the step is a redline change and not an unapproved revised procedure. To do this the changes are documented in red ink.
2. The procedure is traceable to the original document. Original numbering of steps is maintained. Eliminated steps have a line through them.
3. The redlined procedure is readable. If the procedure changes are to the point of making the procedure unreadable, then the procedure should be revised.

PERMANENT REDLINE CHANGES TO A PROCEDURE

A permanent redline is a redline change that will remain in the procedures from that day forward. Permanent redlines should be included in the configuration management copy of the procedure as soon as possible. They can be handwritten in red ink or typed into the procedure in red ink. It is preferred for permanent redline changes to be typed into the procedure prior to future tests as this is easier to read and follow. When the document is revised all permanent redlines will become part of the revision.

ONE-TIME OR TEMPORARY REDLINE CHANGES TO A PROCEDURE

A one-time or temporary redline is a redline change that only affects one operation or a limited series of operations or operating conditions. These redlines should be hand written in red ink or typed into the procedure in red ink. Additionally, the TC or Test Director (TD) should add a note indicating that this is a one-time or temporary redline when typed into the document. When the document is revised usually one-time or temporary redlines would not become part of the revision, except as part of a conditional step for example, “if x condition exist, then perform step y”.

OPERATIONAL REDLINE CHANGES TO A PROCEDURE

During an operation there is often a need to redline a procedure. Once the proper approval as defined by RZ west – OI 61-103, Research and Development Test Operations has been obtained, then the redline changes should be added to the procedure in red ink. If more space is needed, then the words “see back” should be written into the procedure and the changes should be made on the back of the page. After the operation is complete the TC and TD will determine if the redlines are permanent, one-time, or temporary and treat them as such from that point forward.

TYPED IN REDLINES

Redline changes typed into a procedure should be done using the following rules

- The original signature page should be copied and then have in red ink “Redlined (date)” added below the title. See example title page at the end of this paper.
- In the header of the redlined procedure in red ink add “Redlined (date)” under the procedure number. Keep the original release date in the header so that it is traceable to the original procedure. See example title page at the end of this paper.

- When changing content within a procedure step, make the changes in red. Strike through any removed portions of the step. Alternately if the removal and addition of content makes the step harder to read, then the new wording can be added followed by the original wording struck through all in red ink. For example

  ___1.27 RC … steel-toed shoes, Safety glasses, and ~~leather~~ approved gloves.

- When removing a step, strikethrough the step and put the entire step in red ink

  ~~___1.26 TPO Turn **ON** AB data logger in motor configuration.~~

- When adding a step, the step should be added in red ink. The number for the added step should be the previous step number with the letter "a" added behind it. For example, if the step is added after step 4.34, then the added step should be 4.34a. If multiple steps are added between original steps then use sequential letters of the alphabet. By proceeding in this manner the unchanged steps are easily traceable to the original document.

  ___1.26 RC Don……
  ___1.26a RC Remove lateral……
  ___1.27 RC Install…..

- When moving a step, follow the instruction for adding a step in the new location but include the phrase "previously step X" following the new step number or in a note add the phrase "step Y was previously step X"--for example, "4.34a was previously 4.44". At the previous step location in the procedure, leave the step number as originally written but change the wording to "Step moved to (new step number)"--for example, "Step moved to 4.34a".

  Note: The following step 1.24a was previously step 1.28
  ___1.28 Step moved to 1.24a

HANDWRITTEN REDLINES

Handwritten redlines should be in red ink. If more space is needed, then a reference should be made to the back of the page and the changes should be written there.

GUIDANCE FOR WHEN TO MAKE A REVISIONS VERSUS REDLINES

A procedure should be revised when the redline changes cause the procedure to be unreadable. A procedure should be revised when the changes increase the level of risk to a program, remove risk mitigation that was approved by the test approval authority (usually documented in the hazard analysis), or change the operating parameters of the program to something outside the previously accepted range approved by the test approval authority (usually documented in the test plan). A procedure should be revised at the time of its annual review if there are permanent redline changes.

CONCLUSION

AFRL recently wrote a procedure writing guideline incorporating regulation guidance, lessons learned from previous testing, and inputs from 20 test personnel with many years of test experience. This report, presented an overview of the procedure writing guidance. The guidance will prove invaluable to new test engineers as well as a fine reference for seasoned veterans.

SAMPLE REDLINE PROCEDURE TITLE PAGE AND HEADER
TEST OPERATING PROCEDURE

TEST AREA X

TOP 1-XX-1000 Rev. 1

Redlined 12/10/2010

FIRING DATE: _____
FIRING NUMBER: _____

PREPARED BY: _____ Date: _____
Test Engineer

COORDINATED BY: _____ Date: _____
Additional Duties Weapons Safety Manager, if required

APPROVED BY: _____ Date: _____
Program Manager

_____ Date: _____
Test Director

_____ Date: _____
ROSS Operations Manager

_____ Date: _____
ROSS Safety

_____ Date: _____
Weapon Safety Manager

_____ Date: _____
Chief of Safety

_____ Date: _____
Chief, Experimental Demonstration Branch

RECIEVED BY: _____ Date: _____
Configuration Management

AIR FORCE RESEARCH LABORATORY (AFRL)
EDWARDS AIR FORCE BASE, CALIFORNIA 93524-5000

AFRL

THE AIR FORCE RESEARCH LABORATORY

LEAD | DISCOVER | DEVELOP | DELIVER

Procedure Writing Aid

20 April 2011

Daniel Harbour
Dr. Joseph Beasley
Propulsion Directorate
Air Force Research Laboratory

Agenda

- Introduction
- Rules of Thumb
- Procedure Modification
- Procedure Revisions
- Conclusion

Introduction

- **The Air Force Research Laboratory (AFRL) recently established procedure writing guidance to provide a common base for the creation of test procedures.**
  - Procedure writing rules of thumb were created based on previous procedure writing guidance, most in draft form and never published, and from lessons learned.
  - An emphasis was put on the procedure modification process.
  - The guidance was designed as a training aid for new employees and a reference document for those with test experience.

Rules of Thumb

- **Procedure steps should explain what needs to be done in a succinct and clear manner.**
- **As a general rule, steps should only contain one action when possible.**
- **Page breaks should not occur in the middle of paragraphs or steps to ensure continuity and readability for the test team.**

Rules of Thumb

- **Procedures or their prerequisite procedures should first establish a starting state for the system.**
  - This initial system configuration is determined by verifying that all systems are in a known condition at the beginning of the operation.
  - Not verifying the starting state of the system has resulted in propellant flowing or not flowing as expected during operation.

Rules of Thumb

- **Keep wording of steps consistent.**
  - Pick one way of stating things and stick with it
- **Know how procedures link with other procedures.**
  - Some procedures can be completed at the same time without causing a problem, while others have to be performed in series.
- **Procedures should be written so that the TC can properly document step completion.**
  - Providing checkmark spaces located along one side of the page allows consistent documentation of completed steps.
  - Mixing locations for the checking has caused steps to be missed and for incidents to occur

Rules of Thumb

- **Consider the operations day flow when writing procedures.**
  - Operations that do not require a Test Conductor (TC) to actively follow the steps, but just verify they have been completed, should be done in separate checklists.
  - In these separate checklists it should be noted who can run the list (e.g. Red Crew Leader, Instrumentation Crew, Test Panel Operator, etc).
  - This organization allows simultaneous operations and can save several hours during pre-test setup and post-test shutdown.

Rules of Thumb

- **When writing the procedures keep the crew in mind.**
  - Always arrange these steps in a logical order based on physical location to prevent unnecessary crew movement.
  - Include quick reference information for the crew to make the procedure easier to follow. For example, just before a series of steps that are performed at the T-Room, place the phrase (T-room) i.e.

    (T-room)

    RC Verify XXXX.

Procedure Modification Process (Redline Changes)

- **Procedures are maintained in the configuration management office.**
  - The official copy of a procedure is one from configuration management with a tracking number.
  - Configuration management is important to maintain traceability of all procedures to a known system operation and state.
  - Configuration management is mandatory for ensuring old and obsolete procedures are not used and mixed with newer procedures as systems mature and procedures are modified.

Procedure Modification Process (Redline Changes)

Deviations to approved procedures are called redlines at AFRL.

- **The following criteria was used to create the documenting processes for procedure modifications.**
  - It is clear that the step is a redline change and not an unapproved revised procedure. To do this the changes are documented in red ink.
  - The procedure is traceable to the original document. Original numbering of steps is maintained. Eliminated steps have a line through them.
  - The redlined procedure is readable. If the procedure changes are to the point of making the procedure unreadable, then the procedure should be revised.

Procedure Modification Process (Redline Changes)

- Permanent redline changes to a procedure
- One-time or temporary redline changes to a procedure
- Operational redline changes to a procedure
- Two styles of redline changes
  - Typed
  - Handwritten

Procedure Modification Process (Redline Changes)

- **Redline changes typed into a procedure should be done using the following rules**
  - The original signature page should be copied and then have in red ink “Redlined (date)” added below the title.

Procedure Modification Process (Redline Changes)

- **Redline changes typed into a procedure should be done using the following rules (cont.)**
  - When changing content within a procedure step, make the changes in red. Strike through any removed portions of the step. Alternately if the removal and addition of content makes the step harder to read, then the new wording can be added followed by the original wording struck through all in red ink. For example

    ___1.27 RC … steel-toed shoes, Safety glasses, and ~~leather~~ approved gloves.

  - When removing a step, strikethrough the step and put the entire step in red ink

    ~~___1.26 TPO Turn ON AB data logger in motor configuration.~~

Procedure Modification Process (Redline Changes)

- **Redline changes typed into a procedure should be done using the following rules (cont.)**
  - When adding a step, the step should be added in red ink.

___1.26	RC	Don……
___1.26a	RC	Remove lateral……
___1.27	RC	Install…..

Procedure Modification Process (Redline Changes)

- **Redline changes typed into a procedure should be done using the following rules (cont.)**
  - When moving a step, follow the instruction for adding a step in the new location but include the phrase “previously step X” following the new step number or in a note add the phrase “step Y was previously step X”.

Note: The following step 1.24a was previously step 1.28

___1.28 Step moved to 1.24a

Procedure Modification Process (Redline Changes)

- **Handwritten redlines**
  - –Handwritten redlines should be in red ink
  - –Can be any one of the three types of redlines

Procedure Modification Process (Revisions)

- **A procedure should be revised when any of the following are true**
  - The redline changes cause the procedure to be unreadable.
  - The changes increase the level of risk to the program
  - The operating parameters of the program are changed to something outside the previously accepted range approved by the test approval authority.
  - At the time of its annual review if there are permanent redline changes.

Conclusion

- **AFRL recently wrote a procedure writing guideline incorporating regulation guidance, lessons learned from previous testing, and inputs from 20 test personnel with many years of test experience.**
- **This presentation was an overview of the procedure writing guidance and included rules of thumb, a modification guide, and presented styles for redline changes to be referred to as procedures are written.**
- **The guidance will prove invaluable to new test engineers as well as a fine reference for seasoned veterans.**

BACKUP SLIDES

Rules of Thumb

- **Remote valves should be cycled, if safe to do so, early in an operation to verify they are working properly.**
  - This cycling should be done the day of the operation if possible.
  - Valves that worked the previous day have been found to not be working the following day.

Procedure Modification Process (Redline Changes)

- **Permanent redline changes to a procedure**
  - A permanent redline is a redline change that will remain in the procedures from that day forward.
  - Permanent redlines should be included in the configuration management copy of the procedure as soon as possible.
  - When the document is revised all permanent redlines will become part of the revision.

Procedure Modification Process (Redline Changes)

- **One-time or temporary redline changes to a procedure**
  - A one-time or temporary redline is a redline change that only affects one operation or a limited series of operations or operating conditions.
  - When the document is revised usually one-time or temporary redlines would not become part of the revision.

Procedure Modification Process (Redline Changes)

- **Operational redline changes to a procedure.**
  - Once the proper approval has been obtained, then the redline changes should be added to the procedure in red ink.
  - After the operation is complete the TC and TD will determine if the redlines are permanent, one-time, or temporary and treat them as such from that point forward.