Guidelines and Application Procedures for API-RP 578
Positive Material Identification (PMI)
Using XRF and OES Technologies

API Sub Committee Meeting Training Course Explained on
API RP-578
September 19, 2007
By
Don Mears

Introduction:

A. Analytical Training Consultants has written and submitted to API a training course on API-RP 578 for approval by the committee.

B. The Committee has written the Second Edition and is in the Balloting Stage (Ballot 578-01-07).

C. A Committee member of API-RP 578 asked us to speak at this "72nd Fall Refining and Equipment Standards Meeting" and explain:

1. Why should this Course be given?

2. Purpose of the Course

3. Explain the need and requirements for "Positive Material Identification" (PMI) using XRF and OES Technologies

D. Purpose of the Course is to certify and re-certify API 570 inspectors, in understanding and applying API RP 578 through an approved API Training Course that will qualify personnel in proper Guidelines and Application procedures utilizing XRF and OES technologies for PMI.

E. The course will be covered in 2-day sessions and instruction on both classroom theory and field testing procedures.

1. Through Understanding API RP 578 Guidelines

2. Through Application of proper PMI testing procedures

F. The need and now requirement for Positive Material Identification (PMI) has dramatically grown in the past few years in refinery and petrochemical plant operations to 100% alloy material verification in today's risk-based QC environment.

Why should this course be given?

G. **OSHA INSTRUCTION:** Directive number CPL 03-00-004, effective June 7, 2007, which is the "Petroleum Refinery Process safety Management Emphasis Program". The purpose: "this instruction describes policies and procedures for implementing a National Emphasis Program (NEP) to reduce or eliminate the workplace hazards associated with the catastrophic release of highly hazardous chemicals at petroleum refineries.

H. **Safety Bulletin from U.S. Chemical Safety and Hazard Investigation Board (CSB)—BP Texas City**, Texas Refinery Fire that killed 15 and injured 180 people. The CSB Safety Bulletin (see appendix) states: "Positive Material Identification: Prevents Errors during Alloy Steel System Maintenance "

I. **Safety Bulletin form U.S. Chemical Safety and Hazard Investigation Board (CSB) ---Chlorine Transfer Hose Failure** due to improper material braid construction (i.e., 316L and not the recommended braid of Hastelloy C-276). On August 14, 2002 a 1- inch transfer line ruptured during a railcar offloading operation at DPC Enterprises in Festus, Missouri and released 48,000 pounds of Chlorine into neighboring areas.

J. **All the Reported and Unreported "Near Misses" the Oil and Gas Industry has experienced.** Many of us in, this room can give examples of this or has witnessed this happening. Because of either Luck, Proper PMI / inspection, Training, or Recognized and Generally Accepted Good engineering Practices (RAGAGEP) (i.e. API RP 578), we were able to apply these principles and stop the "Near Misses" from turning into Catastrophe.

U.S. DEPARTMENT OF LABOR — OSHA INSTRUCTION — Occupational Safety and Health Administration

DIRECTIVE NUMBER: CPL 03-00-004 **EFFECTIVE DATE: June 7, 2007**
SUBJECT: Petroleum Refinery Process Safety Management National Emphasis Program

Purpose: This Instruction describes policies and procedures for implementing a National Emphasis Program (NEP) to reduce or eliminate the workplace hazards associated with the catastrophic release of highly hazardous chemicals at petroleum refineries.

Scope: This instruction applies OSHA-wide.

References: See below.

State Plan Impact: State adoption is not required**.** See paragraph VII.

Action Offices: National, Regional, and Area Offices (AOs).

Originating Office: Directorate of Enforcement Programs (DEP).

Contact:

Directorate of Enforcement Programs 200 Constitution Avenue, NW, Room N3107 Washington, DC 20210 Phone: (202) 693-1850

Executive Summary

This instruction provides guidance to Occupational Safety and Health Administration (OSHA) national, regional, and Area Offices and state programs which choose to implement a similar program concerning OSHA's policy and procedures for implementing a National Emphasis Program NEP to reduce or eliminate workplace hazards associated with the catastrophic release of highly hazardous chemicals at petroleum refineries.

I. Purpose. This instruction describes an OSHA National Emphasis Program (NEP) for inspecting petroleum refineries (refineries) included in Standard Industrial Classification (SIC) 2911 [North American Industrial Classification System (NAICS) 324110] and contains policies and procedures to verify employers' compliance with OSHA's Process Safety Management (PSM) of Highly Hazardous Chemicals standard, 29 CFR 1910.119.

II. Scope. This instruction applies OSHA-wide.

III. References. The following section refers to documents and websites which are included in this instruction.

For additional references to documents used for process safety in the refining and chemical industries, see OSHA's PSM Safety and Health Topics website. This website provides references for equipment design and in-service practices (e.g., inspection, testing, preventative and predictive maintenance, repair, alteration, rerating and fitness-for-service evaluations) and other important aspects of process safety including process hazard analysis, human factors, facility sitting, fire protection, mechanical integrity, procedures, management-of-change, etc. We have listed the references that should be reviewed.

A. Federal Register, Volume 57, Number 36, pages 6355 to 6417, (including Preamble) February 24, 1992, Final Rule, Process Safety Management (PSM) of Highly Hazardous Chemical; Explosives and Blasting Agents standard; 29 CFR 1910.119.

B. CPL 02-02-045 – (formerly CPL 2-2.45A CH-1) - Process Safety Management of Highly Hazardous Chemicals -- Compliance Guidelines and Enforcement Procedures, September 13, 1994

C. OSHA Instruction CPL 02-00-103 (CPL 2.103), Field Inspection Reference Manual (FIRM), September 26, 1994

D. OSHA Refinery Location List DEP Intranet website

E. API RP 578, Material Verification Program for New and Existing Alloy Piping Systems, 1st Ed., 1998, API

F. Safety Bulletin – Positive Material Verification: Prevent Errors During Alloy Steel Systems Maintenance, BP Texas City, TX Refinery Fire, October, 2006, U.S. Chemical Safety and Hazard Information Board (CSB)

IV. Expiration. This Instruction is in effect until further notice.

V. Application. OSHA compliance personnel shall ensure that the procedures contained in this directive are followed when inspecting the refineries selected under this NEP.

VI. **Action.** OSHA Regional Administrators and Area Directors (AD) must ensure that the Policies and procedures set forth in this directive are followed.

VII. **Federal Program Change.** This instruction describes a Federal program change which establishes a National Emphasis Program (NEP) for inspecting petroleum refineries (SIC 2911/NAICS 324110) to assure compliance with the Process Safety Management of Highly Hazardous Chemicals (PSM) standard, 29 CFR 1910.119. Participation in this national emphasis effort by those States that have refineries within their jurisdiction is strongly encouraged, but is not required. State response/notice of intent regarding this directive is required.

VIII. **Application**. OSHA compliance personnel shall ensure that the procedures contained in this directive are followed when inspecting the refineries selected under this NEP.

The State's response/notice of intent must indicate whether the State will initiate an emphasis program and if so, whether the State's program will be identical to or different from the Federal. If the State's program differs from the Federal, it's implementing policies and procedures are expected to be at least as effective as those in this instruction and must be available for review. The State may either post its different Emphasis Program on its State plan website and provide the link to OSHA or provide information on how a copy may be obtained. (OSHA will provide summary information on the State responses to this instruction on its website.)

IX. **Background**. OSHA is initiating this NEP to address catastrophic releases of *highly hazardous chemicals* (HHC) at refineries. The large number of fatal or catastrophic incidents in the petroleum refining industry indicates the need for a national emphasis program.

The assignment of appropriate IMIS identifier codes for State Emphasis Programs should be coordinated with the Directorate of Information Technology and the Regional Administrator.

Since the PSM standard was promulgated by OSHA in 1992, no other industry sector has had as many fatal or catastrophic incidents related to the release of HHC as the petroleum refining industry (SIC 2911 (NAICS 32411)). According to OSHA's IMIS database, since May 1992, 36 fatality/catastrophe (FAT/CAT) incidents related to HHC releases in the refining industry have occurred. These incidents included 52 employee deaths and 250 employee injuries, 98 of these injuries required hospitalization. The number of refinery FAT/CAT incidents surpasses the combined total of the next three highest industries over the same period (SIC 2899 Chemical Manufacturing, Not Elsewhere Classified (NEC) – 12 FAT/CATs; SIC 2869 Industrial Organic Chemical Manufacturing, NEC – 12 FAT/CATs; and SIC 2892 Explosive Manufacturing – 11 FAT/CATs).

Recent FAT/CAT incidents involving HHC releases at refineries include the massive explosion and fire at the **BP America Refinery in Texas City, TX** on March 23, 2005. During an isomerization unit startup at the refinery, a splitter tower was grossly overfilled with liquid hydrocarbons until the overpressure protection system released the hydrocarbons to a Blowdown drum and stack (Blowdown system). The relieving Hydrocarbons then quickly over-filled the Blowdown system and caused the Blowdown stack to expel heavier-than-air hydrocarbon liquids and vapors into the atmosphere, resulting in the formation of an unconfined vapor cloud in and around the isomerization unit. The vapor cloud then ignited. The ensuing explosions and fires killed 15 employees and injured another 170. Placing non-essential employees in trailers too close to the isomerization unit substantially increased the incident's severity.

On January 19, 2005, another refinery incident killed one employee and caused multiple injuries to other employees at the **Kern Oil Refinery in Bakersfield, California**. At the time of the incident employees were starting-up the refinery's crude unit and were isolating and cleaning a series of three prefractionator reboiler pumps. While using a pressurized steam line to clean the body of one of the pumps, workers overpressurized the pump casing which then catastrophically ruptured, releasing and igniting hot oil that immediately exploded.

At the **Giant Industries Ciniza Refinery near Gallup, New Mexico**, on April 8, 2004, six employees were injured, with 4 of these employees being hospitalized with serious burn injuries when gasoline components were released and ignited. Maintenance workers were removing a malfunctioning pump from the refinery's hydrofluoric acid (HF) alkylation unit when the release occurred. A shut-off valve connecting the pump to a distillation column was to be closed during the maintenance activity. This valve, however, was apparently left in an open position, leading to the release of flammable liquids and vapors which caused subsequent explosions.

The above examples are one of the important reasons for all to practice (RAGAGEP) and the major reason WHY Analytical Training Consultants is developing an API RP 578 Training Course.

"Recognized And Generally Accepted Good Engineering Practice" (RAGAGEP) – are engineering, operation, or maintenance activities based on established codes, standards, published technical reports or recommended practices (RP) or a similar document. RAGAGEPs detail generally approved ways to perform specific engineering, inspection or mechanical integrity activities, such as fabricating a vessel, inspecting a storage tank, or servicing a relief valve (See CCPS [Ref. 33]).

X. Program Procedures.

A. Site Selection.

1. Targeting Sources. Inspections conducted under this NEP will be conducted at all refineries within the scope of this Instruction. These inspections will focus on PSM-covered processes at refineries. Each Area Office (AO), in conjunction

with the Regional Office (RO), shall develop a master list of establishments to be inspected within that AO jurisdiction in accordance with OSHA Instruction CPL 02-00-025. Refinery Identification. Each AO or RO shall prepare a master list of refineries from those listed in the Refinery Location List found on OSHA's DEP Intranet website. This list represents the locations of refineries which have self-reported to Environmental Protection Agency (EPA) under their Risk Management Program (RMP) reporting requirements. Refineries (SIC 2911) that are not included in this list, but are known by the AO or RO, based on local knowledge, to exist in their jurisdictions shall be added to the master list.

Master List Generation: Once the refineries have been identified, the master list of establishments will be generated.

a. Deletions. Based on their familiarity with local refineries, ROs and AOs shall delete from the master list:

b. Any refineries that are known to be out of business, documenting the basis for such determinations;

c. Any refinery establishment which is an approved participant in OSHA's Voluntary Protection Programs (VPP), or in OSHA Consultation's Safety and Health Achievement Recognition Program (SHARP); or

d. Any refinery establishment that has already received an inspection under this NEP.

2. Inspection Scheduling.

Inspections conducted under this NEP shall be scheduled in accordance with the following priorities. Each RO and AO shall prepare a master list of refineries within their respective jurisdictions. The AO will randomly select inspection sites from the master list and any new sites added to the list using the criteria noted in Section A(1)(a) above. The RO/AO must maintain the Master list of refineries for three years after completion of all the inspections conducted under this NEP. (See OSHA Instruction ADM 03-01-005 OSHA Compliance Records.) Inspections conducted under this NEP will be scheduled over a two-year period. Regions are to schedule 40 percent of the inspections conducted under this NEP in the first year and 60 percent in the second year. Regions have the option and are encouraged to complete the scheduled NEP inspections before the second year ends.

Note: Fewer inspections are scheduled in the first year than the second year so that Regions can have more time to train additional Level 1 and Level 2, "PSM inspectors" to be available when most inspections must be conducted. Regions finishing their inspections under this NEP may share inspection resources to help complete all the inspections this NEP requires.

Important information is found in APPENDIX A regarding the "Static List of" Inspection Priority Items (IPI) and contains questions that the Compliance Safety and Health Officer (CSHO)'s are to address in their compliance evaluation of an employer's refinery "Process Safety Management" (PSM) program.

It should be noted that both PMI and proper OPERATOR TRAINING programs are QUESTIONS that the (CSHO) will address to the Owner/Operator as to compliance with their Process Safety Management (PSM) program. Please see the examples below from section E& K Piping for ***PMI and Operator Training:***

XI. PMI—Positive Material Identification Section E.10:

Does the employer ensure that replacement piping is suitable for its process application?

Yes No N/A

If no, possible violations include:

The employer did not follow RAGAGEP when it failed to conduct positive material identification (PMI) testing to ensure that construction materials of replacement/repaired piping were adequate for process conditions (An example RAGAGEP for PMI testing for existing piping systems includes but is not limited to, API RP 578, Material Verification Program for New and Existing Alloy Piping Systems, Section 4.3, and CSB, Safety Bulletin – Positive Material Verification: Prevent Errors During Alloy Steel Systems Maintenance, BP Texas City, TX Refinery Fire);

The employer did not conduct checks and inspections to assure replacement piping was properly installed according to design specifications;

XII. Proper Operator Training Under section K:

Operator Training

1. Use the training records of the five randomly selected operating employees (See document request in Section X.E.3.n), to determine the response to this question. Yes No N/A
   Compliance Guidance: An "A" operator might be required to perform a different set of operating procedures than a "C" operator. Therefore, to determine if the employee has in fact been trained on the specific operating procedures they are expected to perform, cross-reference the specific procedures that an individual operator is expected to perform with the training records of the specific procedures for which the individual operator has received training.

   If no, possible violations include:

   The employer did not provide initial operator training on each specific procedure operators are expected to perform; or

a. The employer did not document the training,
b. The employer did not document the means used to verify the training, or
c. The employer did not verify that the operator understand the training.

2. Based on the employer's explanation of their management of operator refresher training (See document request in Section X.E.3.o.), have the five randomly selected operating employees received, completed, and understood the refresher training (See document request in Section X.E.3.n.)? For each employee who operates a process, has the employer ensured that the employee understands and adheres to the current operating procedures and that the refresher training is provided at least every three years-- more often if necessary?

   Yes No N/A

   If no, possible violations include:

   a. The employer did not provide operator refresher training at least every three years or more often, if necessary (e.g., on a frequency consistent with that determined through consultation with employees); or
   b. The employer did not document the training;
   c. The employer did not determine that the operator understood the training it received; or
   d. The employer did not document how it verified the training.

XIII. Compliance Guidance: Interview operating employees to determine if they are receiving refresher training as required. For an employer that utilizes testing and a minimum passing test score to determine whether employees understand their initial and refresher training, is the testing designed to ensure that the trainee understands the proper procedures associated with those questions the trainee answered incorrectly? Yes No N/A

If no, possible violations include: the employer failed to verify that operating employees understood the training subject matter of the incorrectly answered test questions.

The CSHO must document in the INCIDENT INVESTIGATION REPORT the number of actual and a ***"near-miss"*** incident which has occurred in you plant. A very important part of this is the ***"Factors that contributed to the incident".*** In section Q of Appendix A OSHA list examples and PMI and Training are a part of this list:

Examples of "Factors that contributed to the incident"/"causal factors" can include, but are not limited to:

A. Management system defects – the employer failed to develop and implement a MI program procedure for the inspection, testing and preventative maintenance of critical instrumentation;
B. The employer did not develop or implement appropriate operating procedures;

C. The employer did not conduct a credible PHA resulting in unidentified hazards, unsafe conditions, inadequate controls, or inadequate practices;

D. The employer did not investigate a previous similar actual or near-miss incident;

E. The employer did not design, operate, maintain, inspect, or change (MOC) equipment or equipment systems per RAGAGEP;

F. The employer did not train its employees in its procedure for transferring product from the Chemical X intermediate tank to Reactor 23;

G. The 3-inch reactor transfer line was replaced without conducting a PMI, as a result, the replaced piping that was constructed of an off-specification material failed in a short period of time;

H. The employer's hot work procedure/safe work practice did not include information on the need for operators to check current calibration of the portable combustible gas meter used to ensure areas around hot work operations are absent hazardous concentrations of flammable vapors/gasses;

I. The frequency the host employer evaluated Contractor Y to make sure its employees were following the Refinery Z's HHC Equipment Opening Procedure was less than that specified in the Refinery Z's Contractor's Safety Program, Section CC.DD;

J. The PSI and operating procedures for Process B did not specify the operating limits or the pressure when the safety-instrumented-system activates;

K. The employer's operating procedures were written in an unclear format and the format varied by unit such that operators that worked in multiple units were or could be easily confused;

L. Employees without turnout gear responded to a large fire at Unit X and received 2nd degree burns when a subsequent explosion occurred; and

M. The acid and caustic lines were not labeled at the loading station which resulted in the off-loading of product into the wrong tank and a runaway reaction. Additionally, the PHA for the off-loading area did not consider the human factor issues of contract drivers potentially routing hazardous materials to the wrong process equipment.

Because of the previously discussed information and my experience with both selling and training personnel in the Petrochemical and Refining Oil and Gas business, we at Analytical Training Consultants are producing the PMI Training Course:

For this reason we have been invited to ask you in the industry to review our course and have an open discussion with your input, so it will properly meet your industry needs in development of a "Process Safety Management" (PSM) program. Below is an outline of the discussed training course:

Guidelines and Application Procedures for API-RP 578
Positive Material Identification
(PMI)
Using XRF & OES Technologies

I. THROUGH UNDERSTANDING API RP 578 GUIDELINES (DAY 1)

A. Scope of the Course

1. General

2. Alloy Substitutions in Carbon Steel Systems

3. Roles and Responsibilities

B. Industry References

1. API 570 Pipeline Inspection Code; Inspection, Repair, and Rerating of In-service Piping Systems

2. API 581, Risk-Based Inspection—Base Resource Document

3. API RP 571, Damage Mechanisms Affecting Fixed Equipment in the Refining Industry

4. API RP 939-C, Guidelines for Avoiding Sulfidation Corrosion Failures in Oil Refineries

5. ASME Boiler and Pressure Vessel Code, Section II, Material Specification Part A, Ferrous Materials

6. ASME Boiler and Pressure Vessel Code, Section II, Material Specification Part B, Non Ferrous Materials

7. ASME, Boiler and Pressure Vessel Code, Section II, Material Specification Part C, Welding Rods, Electrodes, and Filler Metals

8. ASME B31.3, Process Piping

9. CSB Bulletin 2005-04-B, Positive Material Verification: Prevent Errors During alloy Steel Systems Maintenance

10. NACE Paper No 03651, Specification for Carbon Steel Materials for Hydrofluoric Acid Alkylation Units

11. Chemical Safety and Hazard Investigation Board, No. 2002-01-SA, Chlorine Transfer Hose Failure

12. The Chlorine Institute, Inc. 1300 Wilson Blvd. Arlington, Va, 222060, www.cl2.com

13. Chemical Safety and Hazard Investigation Board, 2715 K Street, NW. Washington, DC, 20037-1809, www.chemsafety.gov

14. NACE International, 440 South Creek Drive, Houston, Texas, 77084, www.nace.org

15. American Society for Nondestructive Testing, 1711 Arlingate Lane, Columbus, OH 43228, www.asnt.org

16. ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959, www.astm.org

17. "Portable Tools Pack Plenty of Analyzing Power". By James Pasmore, Tom Anderson, Jonathan Shein, Niton LLC, Billerica, Mass

18. Pipe Fabrication Institute (PFI), 655 32nd Avenue, Suite #201, Lachine, Quebec, Canada H8T 3G6-ES22-"Recommended Practice for Color Coding of Piping Materials"

19. Second International Symposium on the Mechanical Integrity of Process Piping MTI Publication No. 48. Edited by J.R. Sims, J.E. Aller, C. Becht, IV, J.T. Reynolds, W. J. Salot, B.J. Sanders, and S. P. Springer. January 1996, Houston, TX USA

20. J.R. Rhodes, T. Florkowski and J. F. Cameron, *Determination of Sulphur and Cobalt in Hydrocarbons using a 147PM/AL Bremstrahlung Source*, U.K.A.E.A. Research Group Report AERE-R3925, Harwell, 1962

21. United States Code of Federal Regulations, Title 21 - Food and Drugs: Part 11, Electronic records; Electronic Signatures

22. Internal Communication, Dr. Volker Thomsen, Thermo Electron Corp, NITON Business Unit

23. OSHA Directorate of Enforcement Programs 200 Constitution Avenue, NW, Room N3107 Washington, DC 20210 Phone: (202) 693-1850

24. OSHA CPL 02-02-045 – (formerly CPL 2-2.45A CH-1) - Process Safety Management of Highly Hazardous Chemicals -- Compliance Guidelines and Enforcement Procedures, September 13, 1994

25. OSHA DIRECTIVE NUMBER: CPL 03-00-004 EFFECTIVE DATE: June 7, 2007 SUBJECT: Petroleum Refinery Process Safety Management National Emphasis Program

C. Terms and Definitions

D. Extent of Material Verification Program

E. Explain use of Material Verification Program Test Methods

F. Field Evaluation of PMI Test result procedures

G. Proper Marking and Record Keeping

H. Review and Testing on Academic Material of API-RP-578

III. THROUGH APPLICATION OF PROPER PMI TESTING PROCEDURES (DAY 2)

A. Using XRF Technology- (Hands-on Application/Demonstration)

1. Review of XRF Technology

   a. Who should use it?

   b. What is XRF – Technology Explained?

   c. When should XRF be used?

   d. Where should XRF be used—Types of Alloys

   e. How should XRF be used—PMI methods and Procedure Guidelines

   f. Why should XRF be used-Percent of PMI needed?

2. Testing Procedures and Operation (Hands-on with Analyzer)

a. Instrument Operation Safety, Radiation Safety, State Regulations and Registration Requirements

b. Instrument power on/off, calibration and reference checking

c. Sample handling, preparing, positioning, accessory tools needed

d. Instrument features, modes, utilities, libraries, field entries, etc.

e. Instrument calculations, Fundamental Parameters (FP) Empirical Calculations, Teach and Match, Spectrum Match

f. Instrument download, upload, PC software features and reports.

B. Using OES Technology-(Hands on application/Demonstration)

1. Review of OES Technology

a. Who should use it?

b. What is OES-Technology Explained?

c. When should OES be used?

d. Where should OES be used—Types of Alloys

e. How should OES be used—PMI Methods and Procedure Guidelines

f. Why should OES be used--Percent of PMI needed?

2. Testing Procedures and Operation (Hands-on with analyzer))

a. Instrument Operation Safety

b. Instrument Power on/off, Calibration and Reference Checking

c. Sample handling, preparing, positioning, accessory tools needed

d. Instrument features modes, utilities, libraries, field entry's etc.

e. Instrument Calculations, Teach and Match (Go NO Go), Spectrum Match

f. Instrument download, upload, PC software features and reports.

C. Review and Testing with XRF/OES Analyzers on Different Alloy Samples

IV. CONCLUSION

A. Review Test Results and Questions

B. Issue Grades Pass/Fail

V. APPENDIX

Summary Comments for Presentation:

"Reasons Why! This Course should be given"

A. OSHA INSTRUCTION D/N CPL-03-00-00-04 Uses Examples:

1. API RP 578
2. Operation Training and Refresher Training

B. Safety Bulletin from U.S. Chemical Safety and Hazard Investigation Board (CSB)—BP Texas City

C. Safety Bulletin form U.S. Chemical Safety and Hazard Investigation Board (CSB)---Chlorine Transfer Hose Failure

D. All the Reported and Unreported "Near Misses" the Oil and Gas Industry has experienced.

ANSWER: YES or NO