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December 18, 2012

Mr. Bill Lindsay
City Manager
City of Richmond
450 Civic Center Plaza, Suite 300
Richmond, CA 94804

Re: Review of Chevron Report Dated December 12, 2012 entitled "Materials Selection for Repair of Damaged Process Piping in High Temperature Sulfidation Service in the No. 4 Crude Unit"

Dear Mr. Lindsay,

At the request of the City of Richmond, I have reviewed the above referenced report to determine if the use of nine percent chromium (9Cr) steel for replacement of fire damaged piping in high temperature sulfidation (HTS) service in the No. 4 Crude Unit meets the requirements of the California Fire Code (CFC). I have also assessed the completeness of Chevron's report as part of my evaluation of Chevron's materials selection for compliance with the CFC. In addition to building and fire code compliance, the Chevron report also discusses the American Petroleum Institute (API) 939-C, Guidelines for Avoiding Sulfidation Corrosion Failures in Oil Refineries and the BP Cherry Point corrosion incident. Although not directly related to compliance with the CFC, in order to provide a more complete review of the Chevron technical report, I have also reviewed Chevron's discussion on API 939-C, and in particular, in light of the BP Cherry Point HTS incident.

It is my understanding that the CFC relies on the use of the American Society of Mechanical Engineers (ASME) 31.3 standard for the design of piping in refineries and the National Fire Protection Association (NFPA) 30 standard Flammable and Combustible Liquids. Based on my understanding from the Richmond Fire Marshal, NFPA 30 does not prescribe specific material specifications for piping systems such as those under review; rather, NFPA 30 states that such piping systems shall meet the material specifications and temperature and pressure limitations of ASME B31.3 when dealing with piping in refineries. ASME 31.3 focuses on mechanical design requirements and does not provide specific guidance on materials selection for specific corrosion concerns such as HTS. Even though ASME 31.3 does not provide specific guidance on materials selection for refinery piping, my understanding is that it contains general considerations for materials as follows:

- ASME 31.3 states that it is the responsibility of the designer to select materials that provide adequate resistance to corrosion that may be encountered in the intended service.
- ASME 31.3 provides a listing of allowable design stress levels for materials that are typically used in refinery piping systems. 9Cr steel is included in this listing along with its appropriate purchase specification for refinery piping which is American Society for Testing Materials (ASTM) A335.

Chevron's Technical Report states that API 939-C identifies carbon steel with adequate silicon, 5Cr, 9Cr, and 300 SS as examples of materials suitable for (HTS) service, depending on various factors. The report references the Modified McConomy Curves, presented in API 939-C, which show the sulfidation corrosion rates of carbon steel with silicon, 5Cr, 9Cr, and 300 SS. According to Chevron, each of these materials may be suitable for HTS service in the Crude Unit, in particular when one takes into account the Crude Unit's operational history. As an expert in refinery corrosion issues, I am familiar with API 939-C as a document that reflects industry experience related to identification of materials for process piping and equipment in oil refineries to avoid sulfidation corrosion failures. API 939-C provides a listing of potentially suitable materials for HTS service, where the selection of specific materials for a given process and unit are dependent upon process conditions, stream composition, and performance of the different materials in HTS service.

Additionally Chevron provided a reasonable explanation for the BP Cherry Point HTS corrosion incident involving 9Cr steel exposed to stagnant flow conditions in a section of piping that is commonly known as a "dead leg". Based on my knowledge of the incident, I agree with Chevron's conclusion that this incident does not suggest that 9Cr is not suitable for HTS service, but that it is important to eliminate "dead leg" sections of piping as much as possible and that it is important to implement industry recognized "dead leg" inspection programs for the "dead legs" that remain in service.

The Chevron Technical Report also discusses the concern for stress corrosion cracking (SCC) of 18Cr-8Ni steel. 9Cr steel is immune to SCC. Chevron reports on 10 incidents of SCC of 18 percent Chromium – 8 percent Nickel (18Cr-8Ni) steel in HTS service in crude units similar to the service for the replacement piping. The report states that SCC results in very fine cracks that are difficult to detect prior to failure, whereas, HTS corrosion of 9Cr steel is more predictable and easier to monitor as it tends to occur more uniformly over the pipe surface. This is consistent with industry experience in regard to SCC of 18Cr-8Ni steel and HTS corrosion of 9Cr steel.

Based on my understanding of the CFC and communication with the Richmond Fire Marshal, it is my conclusion that 9Cr steel meets the requirements of ASME 31.3 and NFPA 30, and as a result, meets the requirements of the CFC. Furthermore, it is my conclusion that Chevron's report is sufficiently complete to determine that Chevron's selection of 9Cr steel is in compliance with the CFC.

Based on my review of API 939-C, it is my conclusion that 9Cr is identified in API 939-C as a suitable material for HTS service, depending upon specific process conditions and stream composition.

Based on the information contained in the Chevron report, it is my opinion that the selection of 9Cr steel is consistent with industry practices.

These opinions are limited to the review and conclusions set forth above, and do not constitute a professional opinion that Chevron should install 9Cr in its repair project.

I hope this letter meets your request. Let me know if you have any questions.

Sincerely,

James McLaughlin

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