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VIBRATION ANALYSIS PINPOINTS VALVE NOISE SOURCE

A REFINERY THAT SHARED A PROPERTY LINE WITH LOCAL RESIDENTS LOCATED AND CORRECTED A WHINING SOUND THAT THREATENED THE PEACE OF THE COMMUNITY.

BY DANIEL EILERS

The beaches and vast expanse of the southern California coast serve as a drawing card both for recreation and residency. Yet while the sound of the ocean can prove refreshing and soothing, excessive noise from businesses, traffic, construction and industrial operations can disrupt and impact the quality of a community.

Such is the case today with a heavily populated, coastal California town that constantly strives to reduce noise and its impact within its urban environment. The city has a noise ordinance that establishes exterior noise standards by land use. The ordinance regulates a variety of noise generators, with a focus on commercial and heavy industrial operations.

One of the operations that is a source of problems is a major "in-town" refinery. However, the refinery constantly works to reduce its disturbances. In a recent case, they pinpointed and removed a noisy valve.

THE REFINERY

When founded over 90 years ago, the refinery was distant from heavily populated areas. Today, however, the refinery complex is tightly surrounded by areas consisting of industrial, commercially-zoned, recreational and residential properties.

Land use to the north of the refinery is primarily residential mixed with some commercial and light industrial zoning. Heavy industrial operations with a small parcel of commercial and multiple-family resi-

dences dominate the west side of the refinery, while to the east is a golf course along with light commercial and heavy industrial zones. The noise problem was most prevalent, however, at the southern length of the refinery, which borders single-family residences, separated from refining processes only by the width of a four-lane avenue.

The oil refinery is configured to produce large volumes of high-value, cleaner-burning gasoline and diesel fuels designed to meet the air quality standards of the California market. It has a capacity of over 300,000 barrels per day, but operates around the clock so the processing units contribute ambient noise to the surrounding neighborhoods. This noise is particularly troubling to residents who live on that southern border.

THE REFINING PROCESS IN A NUTSHELL

To understand the source of the noise, it is helpful to review the refining process itself. This particular refinery receives crude oil both from a marine terminal and by conventional pipeline. The oil is heated and processed in the crude unit for primary distillation and separation into various components. It is processed first in the crude distillation tower where the oil is fractionated into the following streams:

- Liquid and non-liquid petroleum gas products, such as fuel gas, propane and butane.
- Light liquid products (naphtha), which are further upgraded in the naphtha hydrotreater and platformer for subsequent blending into gasoline.
- Middle distillates (kerosene and diesel), which are produced from the middle of the distillation tower. The kerosene goes to either jet fuel blending, the distillate hydrotreater for ultra-low sulphur diesel (ULSD) production or No. 6 fuel blending. The diesel goes to the distillate hydrotreater for ULSD production.
- The material remaining in the bottom of the crude distillation tower (the material is called atmospheric tower bottoms or ATB) is sent to the vacuum tower for further separation.

The vacuum tower operates at less than atmospheric pressure and fractionates the ATB further. Vacuum gas-oil (VGO) recovered from the vacuum tower is then routed to the ISOMAX unit to be upgraded primarily into naphtha, kerosene and ultra-low sulphur diesel. The residual vacuum tower bottoms (VTB) stream is routed to the visbreaker.

THE OFFENDING UNIT

The ISOMAX unit (a unit that runs a patented and licensed hydrocracking process) uses high heat and pressure to upgrade the VGO through catalytic hydrogenation. This process removes contaminants and produces naphtha for gasoline blending and platformer feed, ULSD and jet fuel. The ISOMAX fractionation bottoms (frac bottoms) are sold as a valuable lubricant feedstock.

VALVE NOISE
BROADBAND VS. TONAL

In general, valves in refineries produce two types of noises. They are:

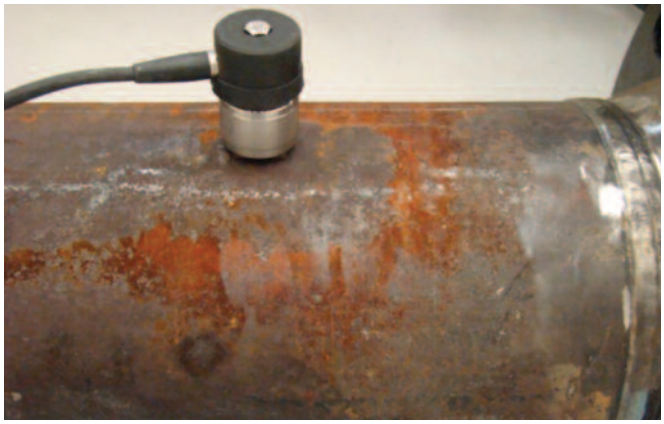
- **Broadband**—Typically, noise generated by valves and piping components is broadband. That means human ears can hear the noise, but it is difficult to distinguish between sources.
- **Tonal**—Valves can also generate tones, but these situations are rare. Tones drive the overall sound pressure level, and therefore the human ear perceives them as being louder than the same overall level from a broadband source.

  Tones are typically generated by a resonance, which can be either mechanical or acoustical in nature.

For many years, very loud harmonic noises (over 113 dBA, refer to Figure 1) were generated somewhere in the ISOMAX process unit near the hydrogen compressors and hydrogen quench control valves. Although the refinery hired an outside consulting firm to determine the exact source of the process unit noise, a problem that had increased over several years, the tests by the consultant were inconclusive.

The problem was exacerbated recently, when the ISOMAX unit began to generate noise that propagated beyond the refinery property line. In fact, the refinery received complaints from nearby

Typical mounting of accelerometer to valve stem.



Magnetic mounting of an accelerometer to a pipe wall.

residents about a continued, high-pitched whine.

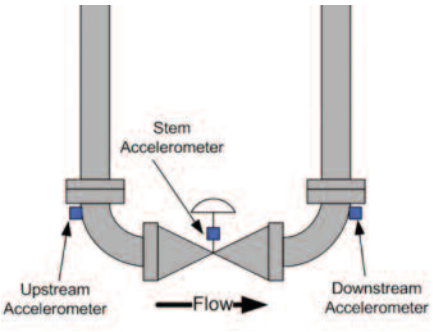
Refinery engineers were uncertain how to resolve the issue since previous studies were inconclusive. Suspecting that control valves could be the potential noise source, they contacted the local business partner of their major valve supplier. Subsequent discussions led to consultation with the valve manufacturer's severe service group, which recommended using vibration-analysis-based, noise measurement equipment and processes.

PINPOINTING THE SOURCE

Since the exact noise source could not be identified using acoustic sound pressure level measurement techniques, which was the process used earlier by the consulting firm, the efforts to measure vibrations began with a survey of the quench valve area to determine where to begin testing.

Accelerometers were used to allow testers to isolate a specific component for analysis, which leads to a systematic evaluation and subsequent elimination of suspect piping and valves.

To determine whether the noise source in this case was upstream of the valves with noise then propagating through the system, the accelerometers were mounted upstream and downstream of the motor-operated valves that feed the quench valves. Following measurements taken at these locations, the sensors then were placed immediately upstream and downstream of each quench valve, as well as mounted on the stem of each valve.



Accelerometers were mounted upstream and downstream of each quench valve as well as on the valve stem.

The highest piping vibration levels were found next to the quench valves, with the highest overall reading being taken on the valve stems. This finding indicated that the source or cause of the noise was most likely the valve trim components.

Stroking the quench valves was shown to impact the tone of the noise. Depending upon the travel, the tones would disappear, increase or change frequency.

The quench valves were 25-year-old units that used post guiding of the valve plug. In such valves, if the tolerance between the plug and valve body is too large, the plug/stem assembly can vibrate. If the assembly is excited at the resonance of the plug/stem component, the vibrations can cause tones.

NEW VALVES SOLVE THE PROBLEM

Working together, refinery engineers and engineers from the local valve sales office identified a valve configuration that could meet the required performance level and eliminate noise concerns.

A cage-guided valve design for high-pressure control requirements was chosen for its more stable operating capability. Also, a digital valve controller was added to each valve to allow optimizing control of the reactor temperature as well as to gain the ability to perform online valve diagnostics. All eight quench valves that were in the ISOMAX unit were replaced with this new valve configuration. The problems with noise were also helped out when the refinery installed a noise monitoring and early warning system to assist in identifying and subsequently controlling unwanted sound.

The result is that the refinery and the nearby community live much more comfortably side by side. **VM**

Figure 1. Noise/Land Use Compatibility

Noise Level	Noise Environment
Below 55 dB	Relatively quiet suburban or urban area
55 – 65 dB	Somewhat noisy urban area, but not directly adjacent to high-volume traffic
65 – 75 dB	Very noisy urban areas, near arterials, freeways or airports
75+ dB	Extremely noisy urban area with potential hearing damage with constant exposure

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