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The Coronavirus Disease (COVID-19) Pandemic, Generation Plant Lessons Learned, and Utility Response

Technical Brief — *Operations Management and Technology*

Coronavirus Disease (COVID-19) Overview

Basic Information

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is the official title of the virus that causes coronavirus disease (COVID-19) and is responsible for the COVID-19 pandemic. The first human cases of COVID-19 were identified in Wuhan, China, in December 2019. In January 2020, the World Health Organization (WHO) declared the COVID-19 outbreak a Public Health Emergency of International Concern. On March 11, 2020, the WHO upgraded the COVID-19 outbreak to a pandemic, a disease prevalent throughout the world. This was based upon two areas of concern noted in the two weeks prior to the pandemic classification: (1) The number of COVID-19 infections outside China had increased 13-fold, and (2) the number of affected countries had tripled. By March 11, 2020, more than 118,000 people were infected in 114 countries, and 4,291 people had already died. By June 2020, more than 9.62 million people were infected in more than 188 countries, there were 489,000 deaths, and 4.85 million people had recovered from infection.

The pandemic had caused a global disruption, both socially and economically. Countries implemented some of the following precautions in response to increased infections:

- Partial or complete lockdowns
- Daytime curfews
- Closure of educational institutions and non-essential businesses
- Bans or number limitation on public gatherings to reduce the number of new infections to within the country's respective health care capabilities

All highly populated events/areas were canceled, such as schools, universities, colleges, religious gatherings, concerts, sporting events, industry conferences/conventions, and so forth. Travel restrictions were also imposed between countries and within countries.

Medical Information

The COVID-19 infection has the following common symptoms:

- Fever or chills
- Cough
- Shortness of breath or difficulty breathing
- Fatigue
- Muscle or body aches
- Headache
- New loss of taste or smell
- Sore throat
- Congestion or runny nose
- Nausea or vomiting
- Diarrhea [1]

The transmission of SARS-CoV-2 can lead to pneumonia and acute respiratory distress syndrome. The time from exposure to the onset of symptoms might range from 2 to 14 days. COVID-19 is most contagious during the first three days after the onset of symptoms, although spread is possible before symptoms appear and from people who are asymptomatic.

The primary method of the virus spread is through close personal contact, most often via small droplets produced by coughing, sneezing, and talking. The droplets usually fall to the ground or onto surfaces rather than traveling through air over long distances. A less common method of the virus spread is by touching a contaminated surface and then touching your face.

Methods to prevent transmission of the virus include the following:

- Handwashing
  - Using soap and water for at least 20 seconds in a deliberate fashion (see Proper Handwashing Technique Video)
  - Hand sanitizer with at least 60% alcohol

CAUTION: Hands are flammable until alcohol dries.

- Avoiding touching your eyes, nose, and mouth with unwashed hands
- Social distancing (at least 6 ft [1.8 m] apart)
- Using a face mask or cloth face-covering when in close contact with others
- Cleaning and disinfecting daily frequently touched surfaces

COVID-19 Impact on the Power Industry

COVID-19 has had a substantial impact on the power industry as the pandemic led to a global reduction in electricity consumption as companies reduced production and many countries instituted shelter-in-place/stay-at-home restrictions. Typically, electric demand was 10% lower than before the pandemic worldwide [2]. Coupled with the lower demand, a reduction in electric market prices also occurred.

As noted in Figure 1, the daily energy impact percentage was directly related to the level of restriction, either by country or region, as in the United States.

Many regional transmission organizations and independent system operators reported not only less electricity demand due to the COVID-19 pandemic, but they also reported a change in the morning load profile (Figure 2). A delay in the morning increase (ramp) resulted as schools, workplaces, and businesses closed to slow the spread of COVID-19.

Generating a Plant Pandemic Response

Shortly after COVID-19 was pronounced a pandemic, utilities began to review their pandemic response plans. The power industry has been viewed as a critical infrastructure for many years, so power plant management had developed emergency response plans that included staffing, temporary facility equipment, and so forth, for various weather or personnel-related events, such as hurricanes, flooding, earthquakes, and previous pandemics like the bird flu.

One of the first critical items reviewed was plant staffing. *Who*, *how many*, and *for how long* were questions that utilities considered to determine the essential personnel required to operate and maintain the plant as the pandemic escalated. Many of the plant emergency response plans addressed plant staffing; however, usually it was for shorter duration events and didn't necessarily focus on minimum staffing levels or any type of personal distancing. With the knowledge of the two-week incubation period for COVID-19, plants began developing staffing rotations to address the incubation period while addressing the site needs. This exercise aided plants when the state and local authorities began issuing stay-at-home restrictions to slow the pandemic increase for the general population. The impact of other closures (schools and day care facilities) also affected plant staffing levels.

Essential Personnel

The determination of essential personnel varied based upon the differing plants. The easy consensus for all plants was that plant operators are essential personnel. After plant operators, essential personnel varied based on several items of consideration, as follows:

- Current plant condition—normal operations, long-term shutdown, outages
- Plant reliability risks—deferred maintenance in place, normal maintenance in place

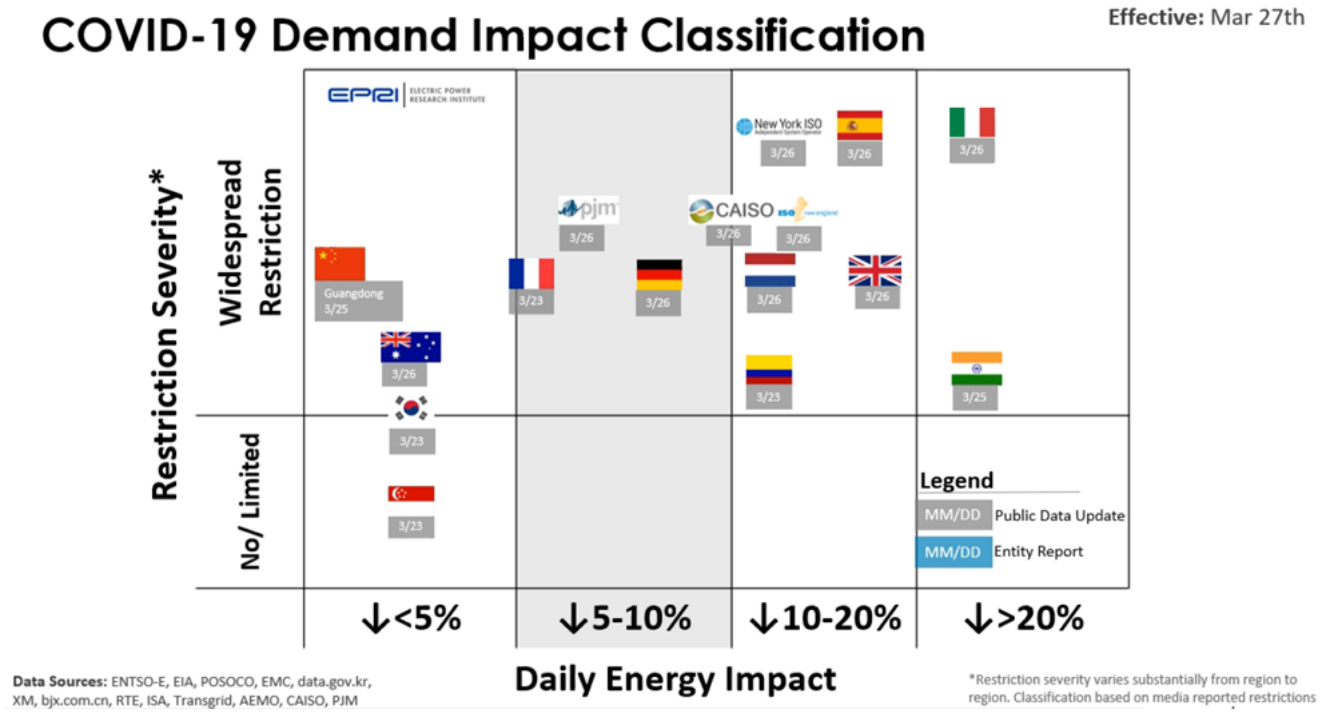

Figure 1. COVID-19 on daily energy impact worldwide

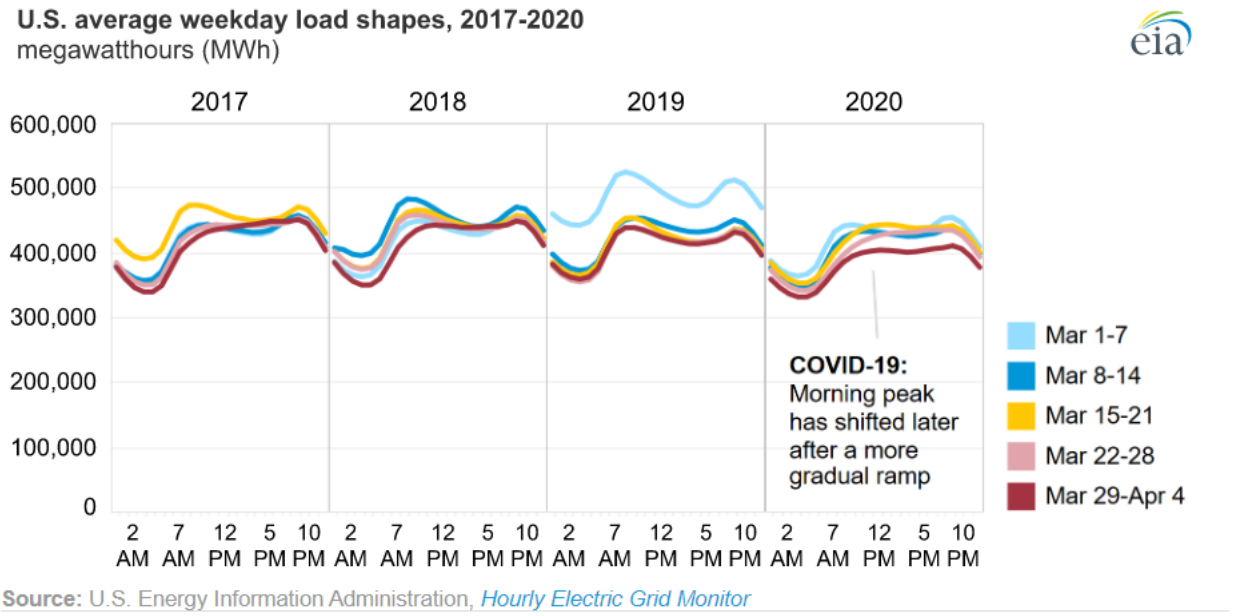

Figure 2. U.S. average weekday load shapes

- Personnel screening methods—types available, screening turnaround times
- COVID-19 area infection rates

Plant maintenance, plant chemistry, fuel handling, plant leadership, and plant engineers were all considered essential personnel in some compacity throughout the industry. The staffing levels of each of these groups also varied from minimum to normal staffing, as determined by the plant management.

Sequestering

As the number of COVID-19-positive cases escalated in regions around the world, power plants sequestered essential personnel to ensure their health while supporting safe and reliable electrical generation. Discussions of sequestration and methods for implementation were a focal point for plant staffs and management decisions. As with the other pandemic challenges, there were many options for sequestration. The first addressed the question of when to sequester. Past plant triggers for sequestration were normally implemented as a result of possible weather-related plant access issues from hurricanes or flooding events or pandemic-related absenteeism, for example, losing 40% of control room operator staff or 20% of instrumentation and control (I&C) teams. With the widely varied governmental guidance, the continued increase in COVID-19-positive cases in the areas, and the continued infrastructural needs for availability to run the plants safely and reliably, some utilities implemented sequestration well below the absenteeism thresholds used in the past as a proactive measure. Other utilities assessed and developed new thresholds for sequestration based upon this ongoing pandemic but never actually implemented sequestration.

Sequestered Plants

Plants sequestered personnel either on-site or off-site, based upon items such as plant layout and location to urban area services. Many plants located in urban locations used hotels as off-site sequester locations. Typically, two shifts of essential personnel were placed into the hotels for 14-day rotations without contact with outside people. Separate entrances, no interaction with hotel staff, catered food, chartered vans, and even security were established at the hotel during sequestration. Other plants sequestered on-site using either existing facilities (for example, office space, visitor centers) or parking lots with temporary living, such as camping trailers (Figure 3). In both sequestration methods, items such as laundry, showers, food, entertainment, and cleaning had to be considered and arranged through either plant staff or contract personnel. Both sequestration methods used two additional shifts sheltering in place at home to rotate in after 14 days.

Figure 3. COVID-19 personnel sequestered in camping trailers

Non-Sequestered Plants

Based upon a company's metrics for sequestration, not all plants implemented formal sequestration for plant operations. However, other means were implemented to provide additional precautions against the COVID-19 infection of essential plant staff. Some sites restricted plant control room access to only control room operators to minimize potential COVID-19 transmission to these personnel. Additional non-sequestered examples of plant staffing were as follows:

- Option 1
  - Sites maintained the normal operations rotation; the maintenance crew was split in half with one half working on-site and the other in reserve.
  - Management was represented by one person from the management team on-site on each weekday.
  - Engineers, Planners, Lab, and Safety and Environmental personnel traveled to the site, as needed, to complete a task and returned home to ready-reserve status.
- Option 2
  - Coal-yard and operators maintained their normal five-week rotation.
  - Plant management and I&C personnel, electricians, engineers, mechanics, and warehouse personnel were split in half. Half of the personnel worked one week while the other half stayed at home, and the groups rotated the following week. Those at home were expected to check e-mail and stay informed with plant conditions.
  - All office personnel—clerical, buyers, finance, and Human Resources—were moved to remote working.
- Option 3
  - Operators and a skeleton crew of mechanics, electricians, chemical technicians, and so forth, continued to work on-site.
  - The rest of the maintenance personnel were at home on call.
  - The plant scheduled at-home, on-call personnel to rotate on-site and provide the on-site crew relief after they were screened to be free of COVID-19 symptoms.
- Option 4 (Units in Outage)
  - Followed normal scheduling for operations staffing (including lab staff).
  - Followed normal scheduling for maintenance, planners, engineers, and site leadership.
  - Followed normal scheduling for coal-handling crews.
  - Office staff, support personnel, matrixed employees in the computerized maintenance management system (CMMS) group, and supply chain personnel were moved to remote-status workers.
- Option 5
  - Followed normal plant staffing, except the administration personnel moved to remote working.
  - Engineers were scheduled as needed, depending on the work scope.
  - Personnel to manage outage work scope were categorized as essential personnel.
- Option 6
  - One utility split the operators and maintenance staff into five teams (A, B, C, D, E), where A and B teams worked 12-hour shifts for 14 days while C and D teams were at rest on standby, and then the team groups swapped. Team E was on standby and used just for emergency cases.

Personnel Screening

After determining how to staff the plant during the pandemic, plants also needed to implement personnel screening methods for COVID-19 to protect against transmission to plant personnel. While COVID-19 testing was used for screening essential personnel, especially for those utilities that implemented sequestration, it was not effective for personnel screening on non-sequestered sites due to the time required (48 hours to a week) before the results were known. Plants developed other methods to screen personnel entering the plant sites daily.

Two methods were used for screening personnel for plant access. All personnel entering the site responded either to a U.S. Centers for Disease Control and Prevention (CDC) style questionnaire and non-contact temperature screenings (threshold value of 100.4°F [38°C]) or to a CDC style questionnaire only (typically because of supply chain issues with non-contact thermometers). Any personnel who answered yes to the screening questions or tested above the threshold for temperature were not allowed into the site and were asked to sequester at home for 14 days.

The personnel temperature screenings were performed by gate security staff, plant health and safety personnel, or contract medical screeners. Some plants not only monitored personnel entering the site, but also offered mid-shift and end-of-shift temperature screenings to plant staff. To effectively use technology, some sites also attempted to use infrared (IR) scanners for temperature monitoring but had very limited success due to the limitations of IR scanning. These limitations included (but were not limited to) the following:

- Distance to the detector
- Detector model
- Actual location of the temperature measurement (tear duct of the eye)
- Line of sight to the subject
- Calibration requirements

For more information, a YouTube video of the Electric Power Research Institute's research on IR camera use for personnel monitoring is provided: https://www.youtube.com/watch?v=_ucwH0-fcW4&feature=youtu.be. Later, in the pandemic timeline, the discovery of asymptomatic personnel also added to the reduced effectiveness of temperature screening.

Pandemic Communication

Good communication is key during an event, such as the pandemic, to provide both actionable information to plant staff and address the natural human desire for transparency, guidance, and making sense out of what is happening during a crisis. Phones, radios, cell phones, video conferencing, e-mail, and plant paging systems are key systems used in a pandemic communication. Some of the most effective methods used for pandemic communications to the plants included the following:

- Utility vice president had conference calls at noon every day (even Saturday and Sunday). The people involved in the various pandemic response roles provided updates on their activities (for example, planning section, logistics section, operations section) with time left for a question and answer (Q&A) session. Normally, there are approximately 150 people on these calls.
  - The information shared during the conference calls was then provided to the plant employees by their supervisors.
- Daily COVID-19 calls with check-ins from each site to discuss sick call-ins, screening test fails, and material needs were implemented.
  - Every Monday, the chief executive officer held a 30-minute weekly webcast with a 5-minute Q&A period.
  - A centralized COVID-19 e-mail address was established.
- Utility established a call and e-mail hotline for employees to report suspected exposure and ask questions.
  - A specific e-mail address for contractors was established as well.

Implementing Remote Workers

While much of the focus was on maintaining plant staffing during the pandemic, plants also had to adjust to remote workers. Depending upon the utility's response for critical staffing, others were deemed non-critical and required to work from home. Day care and school closures also drove the need for personnel to work from home. While most personnel were able to support this with their home systems, using WiFi, there were employees who required hot spot devices/other tools to allow connectivity. During the pandemic time frame, utility focus remained predominantly on essential employees, and the issues or concerns of remote workers were not addressed. To keep plant staff aware and "connected" to the plant, utilities quickly deployed technology tools for COVID-19 communications, such as Microsoft Teams, Webex, In Case of Crisis, Zoom, and Skype.

Cyber Security Considerations

A pandemic, like other natural disasters, can be a time that is seized upon by nation state actors and cyber criminals to try to compromise generation plants. Nation state actors can use the situation to exploit misconfigured or weak security associated with remote access connections, transient cyber assets and removable media, or leverage vendor and supplier relationships. Malware can be delivered that could allow an adversary to maintain persistence on information technology and operational technology (OT) networks, which they could exploit to steal sensitive data (that is, trade secrets, processed data, transactional data, or historical data), implant malicious codes to destroy systems, injure or kill workers, or preposition and maintain access for war planning capabilities.

Likewise, cyber criminals have increased targeting industrial facilities and industrial control systems with malicious codes and ransomware. Recently, a gas compressor station and associated supervisory control and data acquisition systems were compromised by ransomware and had to be fully recovered to restore operations. Another large company recently paid millions of dollars in ransom to have their data unencrypted. With more personnel working remotely, the opportunity for successful malware delivery increases.

The following are some best practices that have been identified that can be quickly implemented or enhanced to prevent cyber attacks:

- Operation's plan of the day to include cyber security impacts for increased awareness, for example, extra personnel on-site working on distributed control system components with transient cyber assets (laptops)
- Implementing multifactor authentication for all remote access into OT networks
- Knowing the actual identity of the person performing the work remotely (utility personnel and vendors)
- Implementing positive control of transient cyber assets and removable media, and only allowing their use with an approved work order
- Scanning removable media and transient cyber assets for malware before and after each use
- Providing additional role-based training for plant staff on cyber threats relative to their daily tasks
- Exercising incident response procedures with plant staff to prepare for a cyber security incident
- Evaluating digital worker tools to ensure that their implementation does not negatively impact the plant's cyber security defense-in-depth strategy

Facilities

Sites also made physical changes to place temporary engineering safeguards and protocols in place to reduce the chance of a COVID-19 spread. Plants installed additional temporary handwash stations along with other safeguards to protect again transmission. Simple personnel behavior changes, such as using non-dominant hand for doors, also provided additional protection. Plants used plexiglass barriers between personnel in areas such as security, lock-out tag-out (LOTO), and various office spaces such as administrative, planners, and management.

Personnel distancing controls were also implemented. These included the following:

- Limitation of one person to a vehicle
- Maximum capacity of two people to an elevator
- Reassignment of plant entrances and exits
- Removal/barricading of large group showers, urinals, and toilets
- Painting, taping, or otherwise marking 6-ft (1.8-m) separation zones at plant waiting areas
- Closure/limited access to small conference rooms or offices
- Shift turnover/crew briefings/work order distribution/pre-job briefs performed remotely or with 6-ft (1.8-m) distancing between attendees
- Staggered break times/lunch times for personnel
- Addition of temporary bathrooms/break areas/lunchrooms
- Physical organization/group isolation from each other (operations, fuel handling, scrubber, maintenance, and chemistry all interact remotely)
- Elimination of sharing resources between sites, including contractors

Along with personnel distancing, plant cleaning practices were adjusted to minimize the chance of COVID-19 infection within the plant. The cleaning varied widely, based upon the plant's perceived risk to personnel; however, a common characteristic of increased frequency and level of cleaning was seen across all utilities. Examples of some good practices in utility cleaning practices were the following:

- Janitorial staff worked seven-day rotations doing full-plant wipe downs on the weekends.
- Many utilities contracted out the deep cleaning to professional contract services on an as-needed basis (Figure 4), especially following a positive test for COVID-19.
- A utility implemented twice-a-day cleaning with a bleach ionizer contractor. Also, hand sanitizers were distributed throughout the plant, and crews were wiping down areas.
- Many plants used fogging for disinfecting for a longer lasting disinfection time period and better coverage.

Figure 4. Deep cleaning the fossil plant control room

- Control room operators disinfected the control room 2–3 times per day.
- Plant personnel were used to clean (at least twice per shift, in addition to coming on duty and going off duty) their often-used areas (for example, break rooms/control center stations/control center bathrooms).
  - These personnel also performed the normal cleaning rounds as janitorial contractors transitioned to being on-site. They also distributed hand sanitizers and disinfecting wipes throughout the plant.
- Plants increased their regular cleaning frequency, with a more detailed focus on high traffic areas and door handles.
- Plants removed water jugs and water fountains and replaced them with individual water bottles.

Safety

Supply Chain and COVID-19 Personnel Protection Equipment

As the COVID-19 pandemic escalated, supply chain shortfalls in pandemic-specific materials rapidly materialized. COVID-19 test kits, medical masks, face shields, gloves, hand sanitizer, and non-contact thermometers became items in high demand but of short supply or were on back order.

Plants adapted to the supply chain shortfalls in several ways. Some manufactured their own hand sanitizer in their chemistry departments. Some reconfigured their thermography equipment to support temperature screening of personnel. Some locally contracted out the manufacture of both face shields and cloth masks for plant personnel use. Some allowed the use of bandanas in lieu of cloth masks.

Operations During COVID-19

Shift Turnover

A best practice for plant operations shift turnover in a 24/7 environment is face-to-face shift turnovers with a formal script of items to discuss. Face-to-face turnovers allowed gestures, eye contact, tones of voice, degrees of confidence, and other redundant and valuable aspects of personal communication to be used when information was exchanged, and the formal script minimizes the human error of forgetting something.

This practice quickly evolved during the pandemic to minimize the spread of COVID-19 while continuing to maintain effective shift turnovers. The additional steps of common equipment/area COVID-19 cleaning by the offgoing watchstander and by the oncoming watchstanders were added to all turnover processes. Other factors that impacted turnover practices besides cleaning were local infection rates, the number of available plant operations personnel, overall health and age of the individuals, implemented sequestration constraints, and technology available. The three methods used during the pandemic are described in detail, as follows:

COVID-19 shift turnover #1, best practice (This method is best because it allows the most face-to-face communications.)

- Individual turnovers process (remote video)
  - When ready to take the shift, the oncoming watchstander used video to step through the scripted turnover checklist and relieve the offgoing watchstander.
  - Another variation of the visual video turnover substituted dedicated turnover computer stations instead of mobile phones and used apps such as Zoom, Webex, Microsoft Teams, and so forth.
- Shift meetings used video meeting apps such as Zoom, Webex, Microsoft Teams, and so forth, allowing personnel to interact remotely.

COVID-19 shift turnover #2, good practice (Face-to-face communications were impacted by mask use.)

- Individual turnovers
  - When ready to take the shift, the watchstanders performed face-to-face turnovers with the addition of 6-ft (1.8-m) distancing and masks.
- Shift meetings maintained face-to-face effectiveness, also using 6-ft (1.8-m) distancing and masks.

COVID-19 shift turnover #3, least preferred practice

- Individual turnovers process (remote non-video)
  - When ready to take the shift, the oncoming watchstander used a phone, radio, and so forth, to step through the scripted turnover checklist and relieve the offgoing watchstander.
- Shift meetings used conference call features, allowing personnel to interact remotely.

Operator Rounds

For equipment and plant reliability, operator rounds are essential. This is another practice that evolved during the pandemic to minimize the COVID-19 spread while continuing with effective operator rounds. Best practices that were used were the following:

- Use of a mobile device and personal device issued to personnel (no sharing)
- Use of a new disposable cover with each person for mobile devices
- Use of paper, no touching of the face, and frequent handwashing/sanitizer use during and after completions of operator rounds

Control Room Aspect

Along with screening personnel entering the plants, some power plants took further measures to protect personnel within the plant, especially control room operators. Many control rooms were isolated to all personnel (in-house personnel and contract personnel), except for other control room operators. All communications and interfacing with the control rooms were performed remotely. The two best practices related to common equipment used in the control room, such as keyboards and mice, were issuing the individual his or her own keyboard/mouse and using a dishwasher safe keyboard/mouse.

Other COVID-19 practices involved more remote communication with outside operators instead of their coming to the control room, using alternative plant control stations during control room deep cleaning, keeping operations groups physically segregated within the shift (that is, control room, outside operators, fuel handling, chemistry, scrubber ops).

Lock-Out, Tag-Out

A key essential process for power plants is LOTO. This typically uses face-to-face interfacing; however, with COVID-19, changes had to be made. The use of a plexiglass barrier between the issuing authority and LOTO holders was a best practice implemented by several utilities. The LOTO holder used a PC and printer on one side of the barrier to generate their isolation list for walkdowns, and then the PC was used to sign onto the LOTO with the software (with no transfer of paper). The lockbox was passed through the plexiglass and made available to the LOTO holder for lock application, returned within the plexiglass barrier, wiped down with cleaner, and returned to the lockbox rack inside the plexiglass area.

Another method used by plants where the control room is also the LOTO offices was the addition of a mobile LOTO center placed outside the control room to prevent personnel entry to the control room for LOTO during the pandemic.

Maintenance During COVID-19

The maintenance group is tasked with performing corrective and preventive maintenance tasks on plant equipment, installing new equipment, and performing LOTO walkdowns. Many times, maintenance personnel work in teams of two in the power plant for performing tasks and for safety aspects. The maintenance group also had to make adjustments to its work practices with the ongoing COVID-19 pandemic. Many changes were implemented to protect the maintenance personnel and provide

plant reliability during the pandemic. This section covers maintenance staffing, outages and plant maintenance, and maintenance of COVID-19 safety.

Staffing

COVID-19 maintenance staffing varied significantly at the plants. This was due to current plant conditions (that is, normal operations, long-term shutdown, outages) and the level of risk that plant management decided upon for plant reliability (that is, deferred maintenance, normal maintenance in place, emergency-only maintenance). Reported maintenance staffing went from full staffing at some plants to no staffing at others. When staffing was less than full complement, some plants began evaluating individual maintenance skills to form new maintenance groups (for example, mechanic/welder, mechanic/machinist, I&C/controls, or I&C/electrical).

Maintenance work hours covered a diverse range as well, as follows:

- Remained the same
- Split up and assigned to shifts
- Split up and assigned days/nights
- Minimum staffing on normal hours with excess personnel sent home
- Sites that sequestered and essential maintenance personnel sequestered also
- Staggered starts/breaks/lunch times implemented to reduce COVID-19 infection

Maintenance personnel sharing between plants was suspended for utilities that practiced this process.

Outages and Plant Maintenance

Plant status during the COVID-19 outbreak affected how maintenance tasks were determined. All plants began using the following:

- Masks
- Remote communications
- A 6-ft (1.8-m) separation
- Single-person tasks when possible

Plants in outage during the COVID-19 outbreak either reduced their outage scope to a critical path only (lower contractor head count) or maintained a normal outage scope. They used distance communication between themselves and contract workers. Phones, video conferencing, and face-to-face through plexiglass barriers became the normal means of communication with the outage workforce.

Plants with spring scheduled outages either deferred them to the fall or operated as "plants in outage," as described previously. Plants that did not have a spring outage performed maintenance based upon what maintenance staffing they had selected for their COVID-19 response. Some plants deferred work during COVID-19 to accommodate the plant's maintenance staffing levels during the pandemic. Maintenance history and equipment criticality were items considered in these decisions. Typical maintenance workloads during the pandemic were the following:

- Performed normal scheduled work (normal maintenance staffing)
- Worked less than a pre-COVID-19 normal scheduled work week due to reduced maintenance personnel on-site
- Worked only safety/regulatory-required maintenance tasks (skeleton maintenance staffing)
- Maintenance responded from home as "on call" only when requested by the plant. Personnel followed plant entrance screening as mentioned earlier when reporting to the site (maintenance staff shelter in place at home).

Maintenance COVID-19 Safety

Some of the maintenance practices that changed during the COVID-19 pandemic included pre-job briefs, work assignment, work segregation, and tool usage.

COVID-19 pre-job briefs continued to be used as an effective human performance tool with the addition of wearing masks and implementing 6-ft (1.8-m) distancing during the pre-job briefing (Figure 5).

Figure 5. Pre-job briefing during COVID-19
Courtesy of TEP

Work assignment methods varied. Plants with worker access to the CMMS were able to allow them to print out assigned jobs without a paper exchange between personnel. Plants without worker access to the CMMS printed out assigned jobs and then distributed them to personnel. The work order distribution had varied as well. Some plants placed the work packages in maintenance staff locations using gloves before staff arrived for the shift, and others distributed work orders using plexiglass barriers and gloves.

COVID-19 safety maintenance during work included work segregation from other maintenance personnel. Masks, 6-ft (1.8-m) distancing, staggered start/stop/break/lunch times, and team assignments were all methods to increase worker safety. Some plants used masks only when workers were less than 6 ft (1.8 m) apart, and others used masks always. Work assignments were performed by individuals as much as possible, or work requiring two individuals was assigned to dedicated teams to minimize

the potential exposure to COVID-19. The dedicated team concept maintained the same two maintenance individuals together on work tasks. If either became sick, both would be sent home; however, since the two individuals did not work with others, it minimized the potential impact to the remaining maintenance staff.

Tool use also became a process requiring modification during COVID-19. Maintenance personnel were directed to not share tools and to clean tools after use (using wipes, soap and water, CDC-approved sprays, ultraviolet sinks, and so forth). Plants encouraged the use of disposable gloves when using the tools to minimize potential exposure. The use of specialty tools caused additional concern, as many plants have a limited number of these. Modified contracts for cleaning these items, which lowered the time that the tool was away from the plant, were implemented with success.

Plant Contractors

With the reduction of in-house maintenance groups, contract workforces have become an integral part of many plant organizations, not only for outages, but also for in-plant daily work. Modifications for minimizing COVID-19 exposure also impacted these contractors.

With the deferral or minimized spring 2020 outages, many outage contractors simply were not on-site to eliminate additional exposure risk to essential plant personnel. Those who were on-site used a phone or video conferencing for communication with plant staff. Physical separation of outage facilities between contractors and plant staff was widely used.

Daily plant contractors followed the same processes as for in-house personnel. Plant entry screening, masks, 6-ft (1.8-m) distancing, gloves, minimal staffing, temporary contract facilities, staggered start/stop/break/lunch times, and dedicated work assignments were all applied to the contract workforce. In some cases, plants used in-house staff and halted all contract work during the pandemic to minimize potential COVID-19 exposure.

Sharing contractors between plants was halted during the pandemic as an effort to minimize the spread of COVID-19, and much of the contract workforce were double screened daily for COVID-19 symptoms, once by their company and then by the plants upon entry.

Plant Deliveries

Power plant deliveries fall into three basic categories: mail, spare parts, and bulk materials (for example, limestone, urea, ammonia, activated carbon, fuel oil). Each of these categories was impacted by COVID-19.

Normal mail and spare parts delivery methods used some of the following processes:

- Proper social distancing between personnel delivering and plant staff
- New temporary mail/spare parts delivery locations segregated from plant staff
- Quarantining of mail/spare parts after delivery for 24–48 hours followed by sanitizing before pickup
- If spare parts delivery required site access, all delivery people were screened with the potential to turn away individuals who tested positive

Bulk material delivery methods included the following:

- Distancing between personnel delivering and plant staff
- All delivery people screened before plant entry with the potential to turn away individuals who tested positive
- New plant processes requiring no invoice/delivery signatures with the driver
- Depending upon the process, the driver performing unloading tasks within the plant under supervision from plant personnel
- Quarantining of mail after delivery for 24–48 hours followed by sanitizing before pickup

Return to Work

By mid-April 2020, many states had announced plans for returning to work and removing the sheltering-at-home mandates. The U.S. Government provided guidance for implementing a three-phased approach for all employees returning to work [3]. Plants also began developing and providing input for return-to-work plans for all their personnel, many mimicking the phased approach.

Some of the items considered for transitioning into the return-to-work and advancing to the next phase were the following:

- Alignment with Federal, state, and local guidance
- Lifting of state and local stay-at-home restrictions
- Downward trajectory in COVID-19 cases reported within the last 14 days
- Total number of active COVID-19 cases in the local area
- Average daily case rate
- Percentage of positive tests compared to the population
- Family welfare conditions (for example, availability of childcare, school closures)
- Site-specific activities completed to ensure the prevention of virus spread
  - Distancing modifications of 6 ft (1.8 m) in group areas, such as break rooms, conference rooms, and cafeterias.
  - COVID-19 personnel protection equipment availability from a supply chain, such as masks, hand sanitizer, cleaning wipes.
  - Process, procedural changes
  - Training personnel for return-to-work protocols

  - Increased cleaning
  - Facility ingress and egress changes
- Status of resources needed to respond to and protect employee health and safety
- Current status of critical infrastructure, such as transportation, health care, and emergency response

The plants also considered triggers for stopping the return-to-work process or even backing up to an earlier phase. Some of these were as follows:

- Federal, state, and local guidance changes
- Local area COVID-19 infection rate increase
- Positive COVID-19 case count increased at the plant site

COVID-19 Second Wave

Since respiratory sicknesses usually occur in waves, speculation began soon after the pandemic started about when the next wave would occur, and what would be the magnitude. This varies widely across the plants, depending upon the government actions taken to mitigate the spread of COVID-19.

In the United States, the medical opinion through June 2020 was that there would be a resurgence of COVID-19 in the fall, but this has changed based upon the July increase in COVID-19 cases in the United States. The U.S. medical community does not expect a recurrence in the fall since many feel that the United States was never out of the first wave of the pandemic. The U.S. medical community believes that fall 2020 will see worse cases because of the continuing COVID-19 pandemic coupled with the normal increase of influenza in the fall.

In other areas of the world, there seem to be two predominant COVID-19 trends. The first is in countries in the Southern hemisphere where successful measures were in place to curtail the first wave of COVID-19 infections; their "fall" has started and a second wave of infections has begun, and current indications show the rate of infections to be higher than that of the first wave. The second wave is in countries where successful measures were in place and then the countries quickly eased restrictions due to economic reasons. In these countries, much like in the United States, the COVID-19 infection rate has again been increasing.

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3002019864 September 2020

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