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DEPARTMENT OF LABOR

Occupational Safety and Health Administration

[Docket No. OSHA-2018-0013]

Salini-Impregilo/Healy Joint Venture: Grant of Permanent Variance

AGENCY: Occupational Safety and Health Administration (OSHA), Labor.

ACTION: Notice of permanent variance.

SUMMARY: In this notice, OSHA grants a permanent variance to Salini-Impregilo/Healy Joint Venture from the provisions of OSHA standards that regulate work in compressed-air environments.

DATES: The permanent variance specified by this notice becomes effective on **[INSERT DATE OF PUBLICATION IN THE FEDERAL REGISTER]** and shall remain in effect until the completion of the Northeast Boundary Tunnel project.

FOR FURTHER INFORMATION CONTACT: Information regarding this notice is available from the following sources:

Press inquiries: Contact Mr. Frank Meilinger, Director, OSHA Office of Communications, phone: (202) 693-1999; email: *meilinger.francis2@dol.gov.*

*General and Technical Information***:** Contact Kevin Robinson, Director, Office of Technical Programs and Coordination Activities, Directorate of Technical Support and Emergency Management, Occupational Safety and Health Administration, U.S. Department of Labor; phone: (202) 693-2110 or email: *robinson.kevin@dol.gov*.

SUPPLEMENTARY INFORMATION:

Copies of this Federal Register notice: Electronic copies of this *Federal Register* notice are available at *http://www.regulations.gov*. This *Federal Register* notice and other relevant information are also available at OSHA's webpage at *http://www.osha.gov*.

I. Overview

On October 19, 2017, OSHA received a variance application from Salini-Impregilo/Healy Joint Venture ("Salini" or "the applicant") regarding the Northeast Boundary Tunnel project, which consists of boring a 12-foot diameter tunnel under a roadway near the Potomac River in Washington, DC. Salini, requested a permanent variance from several provisions of 29 CFR 1926.803, the OSHA standard that regulates construction work in compressed air environments. Specifically, Salini sought a variance from the provisions of the standard that: (1) require the use of the decompression values specified in decompression tables in Appendix A of the compressed-air standard for construction (29 CFR 1926.803(f)(1)); and (2) require the use of automated operational controls and a special decompression chamber (29 CFR 1926.803(g)(1)(iii) and .803(g)(1)(xvii), respectively).

Salini also requested an interim order pending OSHA's decision on the application for a variance (Document ID No. OSHA-2018-0013-0001).

OSHA reviewed Salini's application for the variance and interim order and determined that they were appropriately submitted in compliance with the applicable variance procedures in Section 6(d) of the Occupational Safety and Health Act of 1970 ("OSH Act"; 29 U.S.C. 655) and OSHA's regulations at 29 CFR 1905.11 ("Variances and other relief under section 6(d)"), including the requirement that the applicant inform

workers and their representatives of their rights to petition the Assistant Secretary of Labor for Occupational Safety and Health for a hearing on the variance application.

OSHA reviewed the alternative procedures in Salini's application and preliminarily determined that the applicant's proposed alternatives on the whole, subject to the conditions in the request and imposed by the Interim Order, provide measures that are as safe and healthful as those required by the cited OSHA standards. On August 27, 2019, OSHA published a *Federal Register* notice announcing Salini's application for permanent variance, stating the preliminary determination along with the basis of that determination, and granting the Interim Order (84 FR 44932). OSHA requested comments on each.

OSHA did not receive any comments or other information disputing the preliminary determination that the alternatives were at least as safe as OSHA's standard, nor any objections to OSHA granting a permanent variance. Accordingly, through this notice OSHA grants a permanent variance subject to the conditions set out in this document.

II. Salini and its proposed excavation techniques and safeguards

The information that follows about Salini, its methods, and its project comes from Salini's variance application.

Salini, which is the general contractor for the Northeast Boundary Tunnel Project (hereafter, "the project"), is a contractor that works on complex tunnel projects using innovations in tunnel-excavation methods. Salini's workers engage in the construction of tunnels using advanced shielded mechanical excavation techniques in conjunction with an earth pressure balanced tunnel boring machine (EPBMTBM). Using shielded mechanical excavation techniques, in conjunction with precast concrete tunnel liners and

backfill grout, EPBMTBMs provide methods to achieve the face pressures required to the forward section (the working chamber) of the EPBMTBM.

The project consists of a 12-foot diameter tunnel under a roadway near the Potomac River in Washington, DC. Salini will bore the tunnel below the water table through soft soils consisting of clay, silt, and sand. Salini employs specially trained personnel for the construction of the tunnel, and states that this construction will use shielded mechanical-excavation techniques. Salini's workers perform hyperbaric interventions at pressures greater than 50 p.s.i.g. in the excavation chamber of the EPBMTBM; these interventions consist of conducting inspections and maintenance work on the cutter-head structure and cutting tools of the EPBMTBM.

Salini asserted in the variance application that innovations in tunnel excavation, specifically with EPBMTBMs, have, in most cases, eliminated the need to pressurize the entire tunnel. This technology negates the requirement that all members of a tunnel-excavation crew work in compressed air while excavating the tunnel. These advances in technology modified substantially the methods used by the construction industry to excavate subaqueous tunnels compared to the work regulated by the current OSHA compressed-air standard for construction at 29 CFR 1926.803. Such advances reduce the number of workers exposed, and the total duration of exposure, to hyperbaric pressure during tunnel construction.

Using shielded mechanical-excavation techniques, in conjunction with pre-cast concrete tunnel liners and backfill grout, EPBMTBMs provide methods to achieve the pressures required to maintain a stabilized tunnel face through various geologies, while isolating that pressure to the forward section (working or excavation chamber) of the

EPBMTBM. EPBMTBMs are staffed by trained man-lock attendants and hyperbaric or compressed-air workers.

Interventions involving the working chamber (the pressurized chamber at the head of the EPBMTBM) take place only after the applicant halts tunnel excavation and prepares the machine and crew for an intervention. Interventions occur to inspect or maintain the mechanical-excavation components located in the forward portion of the working chamber. Maintenance conducted in the forward portion of the working chamber includes changing replaceable cutting tools and disposable wear bars, and, in rare cases, making repairs to the cutter head due to structural damage.

In addition to innovations in tunnel-excavation methods, research conducted after OSHA published its compressed-air standard for construction in 1971 resulted in advances in hyperbaric medicine. In this regard, the applicant asserts that the use of decompression protocols incorporating oxygen is more efficient, effective, and safer for tunnel workers than compliance with the existing OSHA standard (29 CFR 1926, subpart S, Appendix A decompression tables). According to the applicant, workers must periodically enter the excavation working chamber of EPBMTBMs to hyperbaric pressures up to 50 p.s.i.g., which does not exceed the maximum pressure specified by the existing OSHA standard (29 CFR 1926.803(e)(5)). The applicant asserts that these hyperbaric exposures are possible because of advances in hyperbaric technology, a better understanding of hyperbaric medicine, and the development of a project-specific Hyberbaric Operations Manual (HOM) that requires specialized medical support and hyperbaric supervision to provide assistance to a team of specially trained man-lock attendants and hyperbaric workers.

Salini contended that the alternative safety measures included in the application provide Salini's workers with a place of employment that is at least as safe and healthful as they would obtain under the existing provisions of OSHA's compressed-air standard for construction.

OSHA included all of the above information in the *Federal Register* notice regarding Salini's variance application and did not receive any comments disputing any of that information, including the safety assertions made by Salini in the Variance application.

III. OSHA History of Approval of Nearly Identical Variance Requests

OSHA has previously approved several nearly identical variances involving the same types of tunneling equipment used for similar projects. OSHA notes that it granted three subaqueous tunnel construction Permanent Variances from the same provisions of OSHA's compressed-air standard (29 CFR 1926.803(f)(1), (g)(1)(iii), and (g)(1)(xvii)) that are the subject of the present application: (1) Impregilo, Healy, Parsons, Joint Venture (IHP JV) for the completion of the Annacostia River Tunnel in Washington, DC (80 FR 50652 (August 20, 2015)); (2) Traylor JV for the completion of the Blue Plains Tunnel in Washington, DC (80 FR 16440 (March 27, 2015)); and (3) Tully/OHL USA Joint Venture for the completion of the New York Economic Development Corporation's New York Siphon Tunnel project (79 FR 29809) (May 23, 2014)). The proposed alternate conditions in this notice are nearly identical to the alternate conditions of the previous Permanent Variances.[1] OSHA is not aware of any injuries or other safety

[1] The other variances allowed further deviation from OSHA standards by permitting employee exposures above 50 p.s.i.g. based on the composition of the soil and the amount of water that will be above the tunnel for various sections of this project. The current proposed variance includes substantively the same safeguards as the variances that OSHA granted previously even though employees will not be exposed to the higher pressures.

issues that arose from work performed under these conditions in accordance with the previous variances.

IV. Applicable OSHA standard and the relevant variances

A. Variance from Paragraph (f)(1) of 29 CFR 1926.803, Requirement to Use OSHA Decompression Tables

OSHA's compressed-air standard for construction requires decompression in accordance with the decompression tables in Appendix A of 29 CFR 1926, subpart S (29 CFR 1926.803(f)(1)). As an alternative to the OSHA decompression tables, the applicant proposes to use newer decompression schedules (the 1992 French Decompression Tables) that rely on staged decompression and supplement breathing air used during decompression with air or oxygen (as appropriate). The applicant asserts decompression protocols using the 1992 French Decompression Tables for air or oxygen as specified by the Northeast Boundary Tunnel-specific Hyperbaric Operations Manual (HOM) are safer for tunnel workers than the decompression protocols specified in Appendix A of 29 CFR 1926, subpart S. Accordingly, the applicant commits to following the decompression procedures described in that HOM, which would require it to follow the 1992 French Decompression Tables to decompress compressed-air workers (CAWs) after they exit the hyperbaric conditions in the working chamber.

Depending on the maximum working pressure and exposure times, the 1992 French Decompression Tables provide for air decompression with or without oxygen. Salini asserts that oxygen decompression has many benefits, including (1) keeping the partial pressure of nitrogen in the lungs as low as possible; (2) keeping external pressure as low as possible to reduce the formation of bubbles in the blood; (3) removing nitrogen from

the lungs and arterial blood and increasing the rate of nitrogen elimination; (4) improving the quality of breathing during decompression stops so that workers are less tired and to prevent bone necrosis; (5) reducing decompression time by about 33 percent as compared to air decompression; and (6) reducing inflammation.

In addition, the project-specific HOM requires a physician certified in hyperbaric medicine to manage the medical condition of CAWs during hyperbaric exposures and decompression. A trained and experienced man-lock attendant also will be present during hyperbaric exposures and decompression. This man-lock attendant will operate the hyperbaric system to ensure compliance with the specified decompression table. A hyperbaric supervisor (competent person), trained in hyperbaric operations, procedures, and safety, directly oversees all hyperbaric interventions, and ensures that staff follow the procedures delineated in the HOM or by the attending physician.

B. Variance from Paragraph (g)(1)(iii) of 29 CFR 1926.803, Automatically Regulated Continuous Decompression

According to the applicant, breathing air under hyperbaric conditions increases the amount of nitrogen gas dissolved in a CAW's tissues. The greater the hyperbaric pressure under these conditions, and the more time spent under the increased pressure, the greater the amount of nitrogen gas dissolved in the tissues. When the pressure decreases during decompression, tissues release the dissolved nitrogen gas into the blood system, which then carries the nitrogen gas to the lungs for elimination through exhalation. Releasing hyperbaric pressure too rapidly during decompression can increase the size of the bubbles formed by nitrogen gas in the blood system, resulting in DCI,

commonly referred to as "the bends." This description of the etiology of DCI is consistent with current scientific theory and research on the issue.

The 1992 French Decompression Tables proposed for use by the applicant provide for stops during worker decompression (i.e., staged decompression) to control the release of nitrogen gas from tissues into the blood system. Studies show that staged decompression, in combination with other features of the 1992 French Decompression Tables such as the use of oxygen, result in a lower incidence of DCI than the use of automatically regulated continuous decompression. OSHA decompression requirements of 29 CFR 1926.803, which specify the use of automatically regulated continuous decompression (see footnotes 5 through 10 below for references to these studies).[2] In addition, the applicant asserts that staged decompression administered in accordance with the project-specific HOM is at least as effective as an automatic controller in regulating the decompression process the HOM includes for at least two reasons:

(1) A hyperbaric supervisor (a competent person experienced and trained in hyperbaric operations, procedures, and safety) directly supervises all hyperbaric interventions and ensures that the man-lock attendant, who is a competent person in the

[2]In the study cited in footnote 6, starting at page 338, Dr. Eric Kindwall notes that the use of automatically regulated continuous decompression in the Washington State safety standards for compressed-air work (from which OSHA derived its decompression tables) was at the insistence of contractors and the union, and against the advice of the expert who calculated the decompression table, who recommended using staged decompression. Dr. Kindwall then states, "Continuous decompression is inefficient and wasteful. For example, if the last stage from 4 psig . . . to the surface took 1 h, at least half the time is spent at pressures less than 2 psig . . . , which provides less and less meaningful bubble suppression . . . ." In addition, the report referenced in footnote 5 under the section titled "Background on the Need for Interim Decompression Tables" addresses the continuous-decompression protocol in the OSHA compressed-air standard for construction, noting that "[a]side from the tables for saturation diving to deep depths, no other widely used or officially approved diving decompression tables use straight line, continuous decompressions at varying rates. Stage decompression is usually the rule, since it is simpler to control."

manual control of hyperbaric systems, follows the schedule specified in the decompression tables, including stops; and

(2) The use of the 1992 French Decompression Tables for staged decompression offers an equal or better level of management and control over the decompression process than an automatic controller and results in lower occurrences of DCI.

C. Variance from Paragraph (g)(1)(xvii) of 29 CFR 1926.803, Requirement of Special Decompression Chamber

The OSHA compressed-air standard for construction requires employers to use a special decompression chamber when total decompression time exceeds 75 minutes (29 CFR 1926.803(g)(1)(xvii)). Another provision of OSHA's compressed-air standard calls for locating the special decompression chamber adjacent to the man lock on the atmospheric pressure side of the tunnel bulkhead (29 CFR 1926.803(g)(2)(vii)). However, since only the working chamber of the EPBMTBM is under pressure, and only a few workers out of the entire crew are exposed to hyperbaric pressure, the man locks (which, as noted earlier, connect directly to the working chamber) are of sufficient size to accommodate the exposed workers. In addition, available space in the EPBMTBM does not allow for an additional special decompression lock. Again, the applicant uses the man locks, each of which adequately accommodates a three-member crew, for this purpose when decompression lasts up to 75 minutes. When decompression exceeds 75 minutes, crews can open the door connecting the two compartments in each man lock during decompression stops or exit the man lock and move into the staging chamber where additional space is available. This alternative enables CAWs to move about and flex their joints to prevent neuromuscular problems during decompression.

V. Decision

After reviewing the proposed alternatives OSHA determined that:

1) Salini developed, and proposed to implement, effective alternative measures to the prohibition of using compressed air under hyperbaric conditions exceeding 50 p.s.i.g. The alternative measures include use of engineering and administrative controls of the hazards associated with work performed in compressed-air conditions up to 50 p.s.i.g. while engaged in the construction of a subaqueous tunnel using advanced shielded mechanical-excavation techniques in conjunction with an EPBMTBM. Prior to conducting interventions in the EPBMTBM's pressurized working chamber, the applicant halts tunnel excavation and prepares the machine and crew to conduct the interventions. Interventions involve inspection, maintenance, or repair of the mechanical-excavation components located in the working chamber.

2) Salini developed, and proposed to implement, safe hyperbaric work procedures, emergency and contingency procedures, and medical examinations for the project's CAWs. The applicant compiled these standard operating procedures into a project-specific HOM. The HOM discusses the procedures and personnel qualifications for performing work safely during the compression and decompression phases of interventions. The HOM also specifies the decompression tables the applicant proposes to use. Depending on the maximum working pressure and exposure times during the interventions, the tables provide for decompression using air, pure oxygen, or a combination of air and oxygen. The decompression tables also include delays or stops for various time intervals at different pressure levels during the transition to atmospheric pressure (i.e., staged decompression). In all cases, a physician certified in hyperbaric

medicine will manage the medical condition of CAWs during decompression. In addition, a trained and experienced man-lock attendant, experienced in recognizing decompression sickness or illnesses and injuries, will be present. Of key importance, a hyperbaric supervisor (competent person), trained in hyperbaric operations, procedures, and safety, will directly supervise all hyperbaric operations to ensure compliance with the procedures delineated in the project-specific HOM or by the attending physician.

3) Salini developed, and proposed to implement, a training program to instruct affected workers in the hazards associated with conducting hyperbaric operations.

4) Salini developed, and proposed to implement, an effective alternative to the use of automatic controllers that continuously decrease pressure to achieve decompression in accordance with the tables specified by the standard. The alternative includes using the 1992 French Decompression Tables for guiding staged decompression to achieve lower occurrences of DCI, using a trained and competent attendant for implementing appropriate hyperbaric entry and exit procedures, and providing a competent hyperbaric supervisor and attending physician certified in hyperbaric medicine, to oversee all hyperbaric operations.

5) Salini developed, and proposed to implement, an effective alternative to the use of the special decompression chamber required by the standard. EPBMTBM technology permits the tunnel's work areas to be at atmospheric pressure, with only the face of the EPBMTBM (i.e., the working chamber) at elevated pressure. The applicant limits interventions conducted in the working chamber to performing required inspection, maintenance, and repair of the cutting tools on the face of the EPBMTBM. The EPBMTBM's man lock and working chamber provide sufficient space for the maximum

crew of three CAWs to stand up and move around, and safely accommodate decompression times up to 360 minutes. Therefore, OSHA determined that the EPBMTBM's man lock and working chamber function as effectively as the special decompression chamber required by the standard.

OSHA conducted a review of the scientific literature regarding decompression to determine whether the alternative decompression method (i.e., the 1992 French Decompression Tables) proposed by the applicant provide a workplace as safe and healthful as that provided by the standard. Based on this review, OSHA determined that tunneling operations performed with these tables[3] result in a lower occurrence of DCI than the decompression tables specified by the standard.[4,5,6]

The review conducted by OSHA found several research studies supporting the determination that the 1992 French Decompression Tables result in a lower rate of DCI than the decompression tables specified by the standard. For example, H. L. Anderson studied the occurrence of DCI at maximum hyperbaric pressures ranging from 4 p.s.i.g.

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[3]In 1992, the French Ministry of Labour replaced the 1974 French Decompression Tables with the 1992 French Decompression Tables, which differ from OSHA's decompression tables in Appendix A by using: (1) staged decompression as opposed to continuous (linear) decompression; (2) decompression tables based on air or both air and pure oxygen; and (3) emergency tables when unexpected exposure times occur (up to 30 minutes above the maximum allowed working time).

[4]Kindwall, EP (1997). Compressed air tunneling and caisson work decompression procedures: development, problems, and solutions. Undersea and Hyperbaric Medicine, 24(4), pp. 337-345. This article reported 60 treated cases of DCI among 4,168 exposures between 19 and 31 p.s.i.g. over a 51-week contract period, for a DCI incidence of 1.44% for the decompression tables specified by the OSHA standard.

[5]Sealey, JL (1969). Safe exit from the hyperbaric environment: medical experience with pressurized tunnel operations. Journal of Occupational Medicine, 11(5), pp. 273-275. This article reported 210 treated cases of DCI among 38,600 hyperbaric exposures between 13 and 34 p.s.i.g. over a 32-month period, for an incidence of 0.54% for the decompression tables specified by the Washington State safety standards for compressed-air work, which are similar to the tables in the OSHA standard. Moreover, the article reported 51 treated cases of DCI for 3,000 exposures between 30 and 34 p.s.i.g., for an incidence of 1.7% for the Washington State tables.

[6]In 1985, the National Institute for Occupational Safety and Health (NIOSH) published a report entitled "Criteria for Interim Decompression Tables for Caisson and Tunnel Workers"; this report reviewed studies of DCI and other hyperbaric-related injuries resulting from use of OSHA's tables. This report is available on NIOSH's website: *http://www.cdc.gov/niosh/topics/decompression/default.html*.

to 43 p.s.i.g. during construction of the Great Belt Tunnel in Denmark (1992-1996);[7] this project used the 1992 French Decompression Tables to decompress the workers during part of the construction. Anderson observed 6 DCS cases out of 7,220 decompression events, and reported that switching to the 1992 French Decompression tables reduced the DCI incidence to 0.08%. The DCI incidence in the study by H. L. Andersen is substantially less than the DCI incidence reported for the decompression tables specified in Appendix A. OSHA found no studies in which the DCI incidence reported for the 1992 French Decompression Tables were higher than the DCI incidence reported for the OSHA decompression tables, nor did OSHA find any studies indicating that the 1992 French Decompression Tables were more hazardous to employees than the OSHA decompression tables.[8]

Based on a review of available evidence, the experience of State Plans that either granted variances (Nevada, Oregon, and Washington)[9] or promulgated a new standard (California)[10] for hyperbaric exposures occurring during similar subaqueous tunnel-construction work, and the information provided in the applicant's variance application, OSHA is granting the permanent variance.

Under Section 6(d) of the Occupational Safety and Health Act of 1970 (29 U.S.C. 655), and based on the record discussed above, the agency finds that when the employer complies with the conditions of the following order, the working conditions of the

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[7]Anderson HL (2002). Decompression sickness during construction of the Great Belt tunnel, Denmark. Undersea and Hyperbaric Medicine, 29(3), pp. 172-188.

[8]Le Péchon JC, Barre P, Baud JP, Ollivier F (September 1996). Compressed air work - French tables 1992 - operational results. JCLP Hyperbarie Paris, Centre Medical Subaquatique Interentreprise, Marseille: Communication a l'EUBS, pp. 1-5 (see Ex. OSHA-2012-0036-0005).

[9]These state variances are available in the docket: Exs. OSHA-2012-0035-0006 (Nevada), OSHA-2012-0035-0007 (Oregon), and OSHA-2012-0035-0008 (Washington).

[10]See California Code of Regulations, Title 8, Subchapter 7, Group 26, Article 154, available at *http://www.dir.ca.gov/title8/sb7g26a154.html*.

employer's workers are at least as safe and healthful as if the employer complied with the working conditions specified by paragraphs (e)(5), (f)(1), (g)(1)(iii), and (g)(1)(xvii) of 29 CFR 1926.803. Therefore, Salini must: (1) comply with the conditions listed below under "Conditions Specified for the Permanent Variance" for the period between the date of this notice and completion of the Northeast Boundary Tunnel Project; (2) comply fully with all other applicable provisions of 29 CFR part 1926; and (3) provide a copy of this *Federal Register* notice to all employees affected by the conditions, including the affected employees of other employers, using the same means it used to inform these employees of the application for a permanent variance. Additionally, this order will remain in effect until one of the following conditions occurs: (1) completion of the Northeast Boundary Tunnel Project; or (2) OSHA modifies or revokes this final order in accordance with 29 CFR 1905.13.

VI. Description of the Conditions Specified for the Permanent Variance

The conditions for the variance are set out in the Order at the end of this document. This section provides additional detail regarding the conditions in the Order.

Condition A: Scope

The scope of the permanent variance limits coverage to the work situations specified under this condition. Clearly defining the scope of the permanent variance provides Salini, their employees, potential future applicants, other stakeholders, the public and OSHA with necessary information regarding the work situations in which the permanent variance applies. To the extent that Salini exceeds the defined scope of this variance, it will be required to comply with OSHA's standards.

Condition B: List of Abbreviations

Condition C defines a number of abbreviations used in the permanent variance. OSHA believes that defining these abbreviations serves to clarify and standardize their usage, thereby enhancing the applicant's and their employees' understanding of the conditions specified by the permanent variance.

Condition C: Definitions

The condition defines a series of terms, mostly technical terms, used in the permanent variance to standardize and clarify their meaning. Defining these terms serves to enhance the applicant's and their employees' understanding of the conditions specified by the permanent variance.

Condition D: Safety and Health Practices

This condition requires the applicant to develop and submit to OSHA an HOM specific to the Northeast Boundary Tunnel at least six months before using the EPBMTBM, proof that the EPMBTBM's hyberbaric chambers have been designed, fabricated, inspected, tested marked, and stamped in accordance with the requirements for ASME PVHO-1.2019 (or the most recent edition of *Safety Standards for Pressure Vessels for Human Occupancy*). These requirements ensure that the applicant develops hyperbaric safety and health procedures suitable for the project.

The submission of the HOM to OSHA, which Salini has already completed, enables OSHA to determine that the specific safety and health instructions and measures it specifies are appropriate to the field conditions of the tunnel (including expected geological conditions), conform to the conditions of the variance, and adequately protect the safety and health of the CAWs. It also facilitates OSHA's ability to ensure that the applicant is complying with these instructions and measures. The requirement for proof

of compliance with ASME PVHO-1.2019 is intended to ensure that the equipment is structurally sound and capable of performing to protect the safety of the employees exposed to hyperbaric pressure.

Additionally, the condition includes a series of related hazard prevention and control requirements and methods (e.g., decompression tables, job hazard analysis (JHA), operations and inspections checklists, incident investigation, and recording and notification to OSHA of recordable hyperbaric injuries and illnesses) designed to ensure the continued effective functioning of the hyperbaric equipment and operating system.

Condition E: Communication

Condition E requires the applicant to develop and implement an effective system of information sharing and communication. Effective information sharing and communication ensures that affected workers receive updated information regarding any safety-related hazards and incidents, and corrective actions taken, prior to the start of each shift. The condition also requires Salini to ensure that reliable means of emergency communications are available and maintained for affected workers and support personnel during hyperbaric operations. Availability of such reliable means of communications enables affected workers and support personnel to respond quickly and effectively to hazardous conditions or emergencies that may develop during EPBMTBM operations.

Condition F: Worker Qualification and Training

This condition requires the applicant to develop and implement an effective qualification and training program for affected workers. The condition specifies the factors that an affected worker must know to perform safely during hyperbaric operations, including how to enter, work in, and exit from hyperbaric conditions under both normal and emergency conditions. Having well-trained and qualified workers performing hyperbaric intervention work ensures that they recognize, and respond appropriately to, hyperbaric safety and health hazards. These qualification and training requirements enable affected workers to cope effectively with emergencies, as well as the discomfort and physiological effects of hyperbaric exposure, thereby preventing worker injury, illness, and fatalities.

Paragraph (2)(e) of this condition also requires the applicant to provide affected workers with information they can use to contact the appropriate healthcare professionals if they believe they are developing hyperbaric-related health effects. This requirement provides for early intervention and treatment of DCI and other health effects resulting from hyperbaric exposure, thereby reducing the potential severity of these effects.

Condition G: Inspections, Tests, and Accident Prevention

Condition G requires the applicant to develop, implement, and operate a program of frequent and regular inspections of the EPBMTBM's hyperbaric equipment and support systems, and associated work areas. This condition helps to ensure the safe operation and physical integrity of the equipment and work areas necessary to conduct hyperbaric operations. The condition also enhances worker safety by reducing the risk of hyperbaric-related emergencies.

Paragraph (3) of this condition requires the applicant to document tests, inspections, corrective actions, and repairs involving the EPBMTBM, and maintain these documents at the job site for the duration of the job. This requirement provides the applicant with information needed to schedule tests and inspections to ensure the continued safe operation of the equipment and systems, and to determine that the actions taken to correct defects in hyperbaric equipment and systems were appropriate, prior to returning them to service.

Condition H: Compression and Decompression

This condition requires the applicant to consult with a designated medical advisor regarding special compression or decompression procedures appropriate for any unacclimated CAW and then implement the procedures recommended by the medical consultant. This provision ensures that the applicant consults with the medical advisor, and involves the medical advisor in the evaluation, development, and implementation of compression or decompression protocols appropriate for any CAW requiring acclimation to the hyperbaric conditions encountered during EPBMTBM operations. Accordingly, CAWs requiring acclimation have an opportunity to acclimate prior to exposure to these hyperbaric conditions. OSHA believes this condition will prevent or reduce adverse reactions among CAWs to the effects of compression or decompression associated with the intervention work they perform in the EPBMTBM.

Condition I: Recordkeeping

Condition I requires the applicant to maintain records of specific factors associated with each hyperbaric intervention. Under OSHA's existing recordkeeping requirements in 29 CFR 1904 regarding Recording and Reporting Occupational Injuries and Illnesses,

Salini must maintain a record of any recordable injury, illness or fatality (as defined by 29 CFR 1904) resulting from exposure of an employee to hyperbaric conditions by completing the OSHA's Form 301 Injury and Illness Incident Report and OSHA's Form 300 Log of Work-Related Injuries and Illnesses. Salini did not seek a variance from this rule and therefore must comply fully with those requirements.

Condition I adds additional reporting responsibilities, beyond those already required by the OSHA rule. Salini is required to maintain records of specific factors associated with each hyperbaric intervention. The information gathered and recorded under this provision, in concert with the information provided under Condition J(using OSHA's Form 301 Injury and Illness Incident Report to investigate and record hyperbaric recordable injuries as defined by 29 CFR 1904.4, 1904.7, 1904.8 - 1904.12), enables the Salini and OSHA to assess the effectiveness of the Permanent Variance in preventing DCI and other hyperbaric-related effects.

Condition J: Notifications

Under this condition, Salini must, within specified periods, notify OSHA and local authorities of any recordable injuries, illnesses, or fatalities that occur as a result of hyperbaric exposures during EPBMTBM operations.

These notification requirements enable the applicant, their employees, and OSHA to determine the effectiveness of the permanent variance in providing the requisite level of safety to the applicant's workers and, based on this determination, whether to revise or revoke the conditions of the permanent variance. Timely notification permits OSHA to take whatever action may be necessary and appropriate to prevent further injuries and

illnesses. Providing notification to employees informs them of the precautions taken by the applicant to prevent similar incidents in the future.

Additionally, this condition also requires the applicant to notify OSHA if it ceases to do business, has a new address or location for their main office, or transfers the operations covered by the permanent variance to a successor company. In addition, the condition specifies that the transfer of the permanent variance to a successor company must be approved by OSHA. These requirements allow OSHA to communicate effectively with the applicant regarding the status of the permanent variance, and expedite the agency's administration and enforcement of the permanent variance. Stipulating that an applicant must have OSHA's approval to transfer a variance to a successor company provides assurance that the successor company has knowledge of, and will comply with, the conditions specified by permanent variance, thereby ensuring the safety of workers involved in performing the operations covered by the permanent variance.

VII. Order

As of the effective date of this final order, OSHA is revoking the interim order granted to the employer on August 27, 2019, and replacing it with a permanent variance order. Note that there are not any substantive changes in the conditions between interim order and the final order.

OSHA issues this final order authorizing Salini to comply with the following conditions instead of complying with the requirements of paragraphs 29 CFR 1926.803(e)(5), (f)(1), (g)(1)(iii), and (g)(1)(xvii). These conditions are:

A. Scope

1. The permanent variance applies only to work:

   a) That occurs in conjunction with construction of the Northeast Boundary Tunnel Project in Washington, DC, a subaqueous tunnel constructed using advanced shielded mechanical-excavation techniques and involving operation of an EPBMTBM;

   b) In the EPBMTBM's forward section (the working chamber) and associated hyperbaric chambers used to pressurize and decompress employees entering and exiting the working chamber.

2. The permanent variance applies only when Salini stops the tunnel-boring work, pressurizes the working chamber, and the CAWs either enter the working chamber to perform interventions (i.e., inspect, maintain, or repair the mechanical-excavation components), or exit the working chamber after performing interventions.

3. Except for the requirements specified by 29 CFR 1926.803(f)(1), (g)(1)(iii), and (g)(1)(xvii), Salini must comply fully with all other applicable provisions of 29 CFR part 1926.

4. This order will remain in effect until one of the following conditions occurs: (1) completion of the Northeast Boundary Tunnel Project; or (2) OSHA modifies or revokes this final order in accordance with 29 CFR 1905.13.

B. List of Abbreviations

Abbreviations used throughout this permanent variance include the following:

1. BWAO – Baltimore/Washington OSHA Area Office
2. CAW – Compressed-air worker

3. CFR – Code of Federal Regulations

4. DCI – Decompression Illness

5. EPBMTBM – Earth Pressure Balanced Moving Tunnel Boring Machine

6. HOM – Hyperbaric Operations and Safety Manual

7. JHA – Job hazard analysis

8. OSHA – Occupational Safety and Health Administration

9. OTPCA – Office of Technical Programs and Coordination Activities

C. Definitions

The following definitions apply to this permanent variance. These definitions supplement the definitions in Salini's project-specific HOM.

1. *Affected employee or worker* – an employee or worker who is affected by the conditions of this permanent variance, or any one of his or her authorized representatives. The term "employee" has the meaning defined and used under the Occupational Safety and Health Act of 1970 (29 U.S.C. 651 et seq.)

2. *Atmospheric pressure* – the pressure of air at sea level, generally 14.7 p.s.i.a., 1 atmosphere absolute, or 0 p.s.i.g.

3. *Compressed-air worker* – an individual who is specially trained and medically qualified to perform work in a pressurized environment while breathing air at pressures up to 50 p.s.i.g.

4. *Competent person* – an individual who is capable of identifying existing and predictable hazards in the surroundings or working conditions that are unsanitary,

hazardous, or dangerous to employees, and who has authorization to take prompt corrective measures to eliminate them.[11]

5. *Decompression illness (also called decompression sickness or the bends)* – an illness caused by gas bubbles appearing in body compartments due to a reduction in ambient pressure. Examples of symptoms of decompression illness include (but are not limited to): joint pain (also known as the "bends" for agonizing pain or the "niggles" for sight pain); areas of bone destruction (termed "dysbaric osteonecrosis"); skin disorders (such as cutis marmorata, which causes a pink marbling of the skin); spinal cord and brain disorders (such as stroke, paralysis, paresthesia, and bladder dysfunction); cardiopulmonary disorders, such as shortness of breath; and arterial gas embolism (gas bubbles in the arteries that block blood flow).[12]

Note: Health effects associated with hyperbaric intervention, but not considered symptoms of DCI, can include: barotrauma (direct damage to air-containing cavities in the body such as ears, sinuses, and lungs); nitrogen narcosis (reversible alteration in consciousness that may occur in hyperbaric environments and caused by the anesthetic effect of certain gases at high pressure); and oxygen toxicity (a central nervous system condition resulting from the harmful effects of breathing molecular oxygen (O_2) at elevated partial pressures).

6. *Earth Pressure Balanced Moving Tunnel Boring Machine* – the machinery used to excavate the tunnel.

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[11]Adapted from 29 CFR 1926.32(f).

[12]See Appendix 10 of "A Guide to the Work in Compressed Air Regulations 1996," published by the United Kingdom Health and Safety Executive and available from NIOSH at *http://www.cdc.gov/niosh/docket/archive/pdfs/NIOSH-254/compReg1996.pdf*

7. *Hot work* – any activity performed in a hazardous location that may introduce an ignition source into a potentially flammable atmosphere.[13]

8. *Hyperbaric* – at a higher pressure than atmospheric pressure.

9. *Hyperbaric intervention* – a term that describes the process of stopping the EPBMTBM and preparing and executing work under hyperbaric pressure in the working chamber for the purpose of inspecting, replacing, or repairing cutting tools and/or the cutterhead structure.

10. *Hyperbaric Operations Manual* – a detailed, project-specific health and safety plan developed and implemented by the employer for working in compressed air during the Northeast Boundary Tunnel.

11. *Job hazard analysis* – an evaluation of tasks or operations to identify potential hazards and to determine the necessary controls.

12. *Man lock* – an enclosed space capable of pressurization, and used for compressing or decompressing any employee or material when either is passing into or out of a working chamber.

13. *Pressure* – a force acting on a unit area; usually expressed as pounds per square inch (p.s.i.).

14. *p.s.i.* – pounds per square inch, a common unit of measurement of pressure; a pressure given in p.s.i. corresponds to absolute pressure.

15. *p.s.i.a* – pounds per square inch absolute, or absolute pressure, is the sum of the atmospheric pressure and gauge pressure. At sea level, atmospheric pressure is

[13]Also see 29 CFR 1910.146(b).

approximately 14.7 p.s.i. Adding 14.7 to a pressure expressed in units of p.s.i.g. will yield the absolute pressure, expressed as p.s.i.a.

16. *p.s.i.g.* – pounds per square inch gauge, a common unit of pressure; pressure expressed as p.s.i.g. corresponds to pressure relative to atmospheric pressure. At sea level, atmospheric pressure is approximately 14.7 p.s.i. Subtracting 14.7 from a pressure expressed in units of p.s.i.a. yields the gauge pressure, expressed as p.s.i.g.

17. *Qualified person* – an individual who, by possession of a recognized degree, certificate, or professional standing, or who, by extensive knowledge, training, and experience, successfully demonstrates an ability to solve or resolve problems relating to the subject matter, the work, or the project.[14]

18. *Working chamber* – an enclosed space in the EPBMTBM in which CAWs perform interventions, and which is accessible only through a man lock.

D. Safety and Health Practices

1. Salini must implement the most recent project-specific HOM previously submitted to OSHA on February 1, 2018. The HOM shall provide the governing safety and health requirements regarding hyperbaric exposures during the tunnel-construction project.

2. Salini must implement the safety and health instructions included in the manufacturer's operations manuals for the EPBMTBM, and the safety and health instructions provided by the manufacturer for the operation of decompression equipment.

3. Salini must use air as the only breathing gas in the working chamber.

[14]Adapted from 29 CFR 1926.32(m).

4. Salini must use the 1992 French Decompression Tables for air, air-oxygen, and oxygen decompression specified in the HOM, specifically the tables titled "French Regulation Air Standard Tables."

5. Salini must equip man-locks used by their employees with an oxygen-delivery system as specified by the HOM. Salini must not store oxygen or other compressed gases used in conjunction with hyperbaric work in the tunnel.

6. Workers performing hot work under hyperbaric conditions must use flame-retardant personal protective equipment and clothing.

7. In hyperbaric work areas, Salini must maintain an adequate fire-suppression system approved for hyperbaric work areas.

8. Salini must develop and implement one or more JHAs for work in the hyperbaric work areas, and review, periodically and as necessary (e.g., after making changes to a planned intervention that affects their operation), the contents of the JHAs with affected employees. The JHAs must include all the job functions that the risk assessment[15] indicates are essential to prevent injury or illness.

9. Salini must develop a set of checklists to guide compressed-air work and ensure that employees follow the procedures required by this permanent variance (including all procedures required by the HOM, which this permanent variance incorporates by reference). The checklists must include all steps and equipment functions that the risk assessment indicates are essential to prevent injury or illness during compressed-air work.

[15]See ANSI/AIHA Z10-2012, American National Standard for Occupational Health and Safety Management Systems, for reference.

10. Salini must ensure that the safety and health provisions of the HOM adequately protect the workers of all contractors and subcontractors involved in hyperbaric operations.[16]

E. Communication

1. Prior to beginning a shift, Salini must implement a system that informs workers exposed to hyperbaric conditions of any hazardous occurrences or conditions that might affect their safety, including hyperbaric incidents, gas releases, equipment failures, earth or rock slides, cave-ins, flooding, fires, or explosions.

2. Salini must provide a power-assisted means of communication among affected workers and support personnel in hyperbaric conditions where unassisted voice communication is inadequate.

a. Salini must use an independent power supply for powered communication systems, and these systems must operate such that use or disruption of any one phone or signal location will not disrupt the operation of the system from any other location.

b. Salini must test communication systems at the start of each shift and as necessary thereafter to ensure proper operation.

F. Worker Qualification and Training

Salini must:

1. Ensure that each affected worker receives effective training on how to safely enter, work in, exit from, and undertake emergency evacuation or rescue from, hyperbaric conditions, and document this training.

[16]See ANSI/ASSE A10.33-2011, American National Standard for Construction and Demolition Operations – Safety and Health Program Requirements for Multi-Employer Projects, for reference.

2. Provide effective instruction, before beginning hyperbaric operations, to each worker who performs work, or controls the exposure of others, in hyperbaric conditions, and document this instruction. The instruction must include topics such as:

a. The physics and physiology of hyperbaric work;

b. Recognition of pressure-related injuries;

c. Information on the causes and recognition of the signs and symptoms associated with decompression illness, and other hyperbaric intervention-related health effects (e.g., barotrauma, nitrogen narcosis, and oxygen toxicity).

d. How to avoid discomfort during compression and decompression; and

e. Information the workers can use to contact the appropriate healthcare professionals should the workers have concerns that they may be experiencing adverse health effects from hyperbaric exposure.

3. Repeat the instruction specified in paragraph (2) of this condition periodically and as necessary (e.g., after making changes to their hyperbaric operations).

4. When conducting training for their hyperbaric workers, make this training available to OSHA personnel and notify OTPCA the BWAO before the training takes place.

G. Inspections, Tests, and Accident Prevention

1. Salini must initiate and maintain a program of frequent and regular inspections of the EPBMTBM's hyperbaric equipment and support systems (such as temperature control, illumination, ventilation, and fire-prevention and fire-suppression systems), and hyperbaric work areas, as required under 29 CFR 1926.20(b)(2) by:

a.Developing a set of checklists to be used by a competent person in conducting weekly inspections of hyperbaric equipment and work areas; and

b. Ensuring that a competent person conducts daily visual checks, as well as weekly inspections of the EPBMTBM.

2. If the competent person determines that the equipment constitutes a safety hazard, Salini must remove the equipment from service until it corrects the hazardous condition and has the correction approved by a qualified person.

3. Salini must maintain records of all tests and inspections of the EPBMTBM, as well as associated corrective actions and repairs, at the job site for the duration of the job.

H. Compression and Decompression

Salini must consult with their attending physician concerning the need for special compression or decompression exposures appropriate for CAWs not acclimated to hyperbaric exposure.

I. Recordkeeping

Salini must maintain a record of any recordable injury, illness, or fatality (as defined by 29 CFR part 1904 Recording and Reporting Occupational Injuries and Illnesses) resulting from exposure of an employee to hyperbaric conditions by completing the OSHA's Form 301 Injury and Illness Incident Report form and OSHA's Form 300 Log of Work-Related Injuries and Illnesses.

Examples of important information to include on the OSHA's Form 301 Injury and Illness Incident Report (along with the corresponding question on the form) are:

Q14

- the task performed;

- the composition of the gas mixture (e.g., air or oxygen);
- an estimate of the CAW's workload;
- the maximum working pressure;
- temperature in the work and decompression environments;
- unusual occurrences, if any, during the task or decompression

Q15

- time of symptom onset;
- duration between decompression and onset of symptoms

Q16

- type and duration of symptoms;
- a medical summary of the illness or injury

Q17

- duration of the hyperbaric intervention;
- possible contributing factors;
- the number of prior interventions completed by the injured or ill CAW; and the pressure to which the CAW was exposed during those interventions. [17]

In addition to completing the OSHA's Form 301 Injury and Illness Incident Report form and OSHA's Form 300 Log of Work-Related Injuries and Illnesses, the employer must maintain records of:

1. The date, times (e.g., began compression, time spent compressing, time

[17]See 29 CFR 1904 Recording and Reporting Occupational Injuries and Illnesses *(http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9631)*; recordkeeping forms and instructions *(http://www.osha.gov/recordkeeping/RKform300pkg-fillable-enabled.pdf)*; and OSHA Recordkeeping Handbook *(http://www.osha.gov/recordkeeping/handbook/index.html*).

performing intervention, time spent decompressing), and pressure for each hyperbaric intervention.

2. The name of each individual worker exposed to hyperbaric pressure and the decompression protocols and results for each worker.

3. The total number of interventions and the total hyperbaric exposure duration at each pressure.

4. The results of the post-intervention physical assessment of each CAW for signs and symptoms of decompression illness, barotrauma, nitrogen narcosis, oxygen toxicity or other health effects associated with work in compressed air or mixed gases for each hyperbaric intervention.

J. Notifications

1. To assist OSHA in administering the conditions specified herein, the employer must:

a. Notify the OTPCA and the Baltimore/Washington OSHA Area Office of any recordable injury, illness, or fatality (by submitting the completed OSHA's Form 301 Injury and Illness Incident Report form[18]) resulting from exposure of an employee to hyperbaric conditions, including those exposures that do not require recompression treatment (e.g., nitrogen narcosis, oxygen toxicity, barotrauma), but still meet the recordable injury or illness criteria of 29 CFR 1904. The employer shall provide the notification within 8 hours of the incident or 8 hours after becoming aware of a recordable injury, illness, or fatality, and submit a copy of the incident investigation (OSHA's Form 301 Injury and Illness Injury Reporting Form) within 24 hours of the

[18]See footnote 4.

incident or 24 hours after becoming aware of a recordable injury, illness, or fatality. In addition to the information required by the OSHA's Form 301 Injury and Illness Injury Reporting Form, the incident-investigation report must include a root-cause determination, and the preventive and corrective actions identified and implemented.

b. Provide certification within 15 days of the incident that the employer informed affected workers of the incident and the results of the incident investigation (including the root-cause determination and preventive and corrective actions identified and implemented).

c. Notify the OTPCA and the Baltimore/Washington OSHA Area Office within 15 working days in writing of any change in the compressed-air operations that affects the employer's ability to comply with the conditions specified herein.

d. Upon completion of the Northeast Boundary Tunnel, evaluate the effectiveness of the decompression tables used throughout the project, and provide a written report of this evaluation to the OTPCA and the Baltimore/Washington OSHA Area Office.

Note: The evaluation report is to contain summaries of: (1) the number, dates, durations, and pressures of the hyperbaric interventions completed; (2) decompression protocols implemented (including composition of gas mixtures (air and/or oxygen), and the results achieved; (3) the total number of interventions and the number of hyperbaric incidents (decompression illnesses and/or health effects associated with hyperbaric interventions as recorded on OSHA's Form 301 Injury and Illness Incident Report and OSHA's Form 300 Log of Work-Related Injuries and Illnesses, and relevant medical

diagnoses and treating physicians' opinions); and (4) root causes of any hyperbaric incidents, and preventive and corrective actions identified and implemented.

e. To assist OSHA in administering the conditions specified herein, inform the OTPCA and the Baltimore/Washington OSHA Area Office as soon as possible after it has knowledge that it will:

i. Cease to do business;

ii. Change the location and address of the main office for managing the tunneling operations specified herein; or

iii. Transfer the operations specified herein to a successor company.

f. Notify all affected employees of this permanent variance by the same means required to inform them of the application for a variance.

g. This permanent variance cannot be transferred to a successor company without OSHA approval.

VIII. Authority and Signature

Loren Sweatt, Principal Deputy Assistant Secretary of Labor for Occupational Safety and Health, authorized the preparation of this notice. Accordingly, the agency is issuing this notice pursuant to Section 29 U.S.C. 655(6)(d), Secretary of Labor's Order No. 1-2012 (77 FR 3912, Jan. 25, 2012), and 29 CFR 1905.11.

Signed at Washington, DC, on May 5, 2020.

Loren Sweatt,

Principal Deputy Assistant Secretary of Labor for Occupational Safety and Health.

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