



U.S. Department  
of Transportation

**Pipeline and Hazardous  
Materials Safety  
Administration**

**September 01, 2022**

1200 New Jersey Avenue, SE  
Washington, DC 20590

DOT-SP 14149  
(SIXTY-FOURTH REVISION)

**EXPIRATION DATE: 2026-07-31**

(FOR RENEWAL, SEE 49 CFR 107.109)

1. GRANTEE: Hexagon Digital Wave LLC  
Englewood, CO
2. PURPOSE AND LIMITATION:
  - a. This special permit authorizes the use of DOT Specification 3AL cylinders and cylinders manufactured under DOT-SP 12440 for the transportation in commerce of the compressed gases described in paragraph 6 below, when retested by a 100% ultrasonic examination in lieu of the internal visual and the hydrostatic retest. This special permit provides no relief from the Hazardous Materials Regulations (HMR) other than as specifically stated herein. The most recent revision supersedes all previous revisions.
  - b. The safety analyses performed in development of this special permit only considered the hazards and risks associated with transportation in commerce.
  - c. No party status will be granted to this special permit.
3. REGULATORY SYSTEM AFFECTED: 49 CFR Parts 106, 107 and 171-180.
4. REGULATIONS FROM WHICH EXEMPTED: 49 CFR §§ 172.203(a) and 172.301(c) in that marking the special permit number is waived; and § 180.205 in that the ultrasonic examination (UE) is performed in lieu of the specified internal visual examination and hydrostatic pressure test for DOT 3AL cylinders made from AA 6061 and cylinders manufactured under DOT-SP 12240 and that ultrasonic examination (UE) and eddy current examination (EE) are performed in lieu of the specified internal visual examination and hydrostatic pressure test for DOT 3AL cylinders made from AA 6351.

Tracking Number: 2022075441

**NOTE:** This does not relieve the grantee of this special permit from securing and maintaining a valid approval for retesting cylinders from the Associate Administrator for Hazardous Materials Safety.

5. **BASIS:** This special permit is based on Hexagon Digital Wave LLC's application dated July 22, 2022 and submitted in accordance with § 107.109.
6. **HAZARDOUS MATERIALS (49 CFR 172.101):**

Hazardous Materials Description			
Proper Shipping Name	Hazard Class/ Division	Identification Number	Packing Group
Liquefied or non-liquefied compressed gases, or mixtures of such compressed gases, classed as Division 2.1 (flammable gas), Division 2.2 (nonflammable gas), or Division 2.3, (gases which are Toxic by Inhalation (TIH)), which are authorized in the Hazardous Materials Regulations for transportation in DOT 3AL cylinders and cylinders manufactured under DOT-SP 12440	2.1, 2.2, or 2.3, as appropriate	As appropriate	N/A

7. **SAFETY CONTROL MEASURES:**

a. **PACKAGING:** Packaging prescribed is a DOT Specification 3AL cylinder, manufactured from aluminum alloy 6061 or 6351, or a cylinder manufactured under DOT-SP 12440 that is subjected to periodic retesting, reinspection and marking prescribed in § 180.205, except that the cylinder is examined by an ultrasonic method in lieu of the hydrostatic pressure test and internal visual inspection. Each cylinder must be subjected to an external visual examination and retested and marked in accordance with the UE procedure described herein and the DWC January 25, 2005 application for special permit on file with the Office of Hazardous Materials Safety (OHMS).

Additionally, DOT cylinders made of aluminum alloy 6351 must be examined by the eddy current (EE) procedure described herein and the DWC January 25, 2005 application for special permit on file with OHMS. A cylinder that has been exposed to fire or to excessive heat may not be retested under the terms of this special permit.

b. Equipment and Performance:

(1) Ultrasonic System: The ultrasonic equipment performance must conform to the DWC's February 1, 2005 application on file with OHMS and as prescribed in this special permit. The UE equipment incorporates a single-channel or a multi-channel immersion system arranged to perform straight and angle beam examinations. The ultrasonic pulses must enter into the cylinder wall in both longitudinal, both circumferential directions and normal to the cylinder wall to ensure 100 percent coverage of the cylinder wall. The system must be set-up to perform longitudinal ultrasonic angle beams from the cylinder shoulder down to the cylinder base area and from the cylinder base up to the cylinder shoulder. Also, the system must be set-up to perform circumferential ultrasonic angle beams in both clockwise and counterclockwise rotation around the cylinder. All defects (such as isolated pits, line corrosion, sidewall defects (e.g. cracks, folds) and line corrosion must be detected. The transducer or cylinder must be arranged so that the ultrasonic beams enter into the cylinder wall and measure thickness and detect the sidewall flaws. The immersion UE system must have a high-speed board to digitize and capture each A-scan during examination of the cylinder. Gain control accuracy must be checked for a new Ultrasonic System with equipment that is calibrated in accordance with industry standards for checking gain linearity accuracy as published in the ASTM-E317 standard. Search units of 2.25 to 10 MHz nominal frequency and 1/4" to a 1" diameter must be used during ultrasonic examination. A manual contact shear or longitudinal search unit may be used for confirmation and sizing of an indicated defect. If manual UE is used, it must be performed under direct supervision of a Senior Review Technologist by a minimum Level II operator and in accordance with American Society of Testing Materials (ASTM) practice E 213.

(2) Eddy Current Equipment: Equipment, such as Visual Plus or Visual Eddy, must be capable of detecting the notches on the standard reference ring.

c. Standard References:

(1) UE Reference Cylinder: A cylinder or a cylinder section must be used as a standard reference and must have similar acoustic properties, surface finish and metallurgical condition as the cylinders under test. The standard reference, (reference cylinder) must have a known minimum design wall thickness ( $t_m$ ) which is less than or equal to the cylinder under test. The standard reference cylinder for cylinders less than or equal to 6-inches in diameter must have the same nominal diameter as the cylinder being tested with a tolerance of +0%/-30%.

Cylinders greater than 6-inches in diameter must conform to the allowable size ranges shown in the following table:

Standard Reference	Cylinder Size Ranges being retested by UE	
	Minimum (OD-inches)	Maximum (OD-Inches)
7	6.30	10.50
7.50	6.75	11.25
9.00	8.10	13.50
9.25	8.33	13.88
10.00	9.00	15.00
12.00	10.80	18.00

Prior to placing the simulated defects, such as minimum wall thickness, the average minimum wall thickness for the standard reference must be determined by means of an independent method.

(2) The standard reference (reference cylinder) must be prepared to include the following artificial defects:

- (i) The artificial defect for area corrosion will be 0.70 square inch (in<sup>2</sup>) and the remaining wall thickness must be at least the design minimum wall for a cylinder being tested.
- (ii) The artificial defect for isolated pits in cylinders less than or equal to 4 inches in diameter consisting of an internal flat bottom hole (FBH) of 1/8 inch diameter and 1/3t<sub>m</sub> in depth.
- (iii) The artificial defect for isolated pits in cylinders greater than 4 inches in diameter consisting of an internal FBH of 1/4 inch diameter and 1/3t<sub>m</sub> in depth.
- (iv) The artificial defect for line corrosion consisting of two circumferential (one internal and one external) and two longitudinal (one internal and one external) notches. These notches shall be electro discharge machine (EDM), measuring 0.10 t<sub>m</sub> in depth, 1 inch in length and less than or equal to 0.010 inch width.

(3) A certification statement signed by a Hexagon Digital Wave LLC senior review technologist (SRT) must be available for all standard references at each site

where retesting is performed. The certification statement must include a standard reference drawing for each size of cylinder. A standard reference drawing must include dimensions and the locations of each simulated defect.

(4) Eddy Current Reference Ring: The reference ring must be produced to represent one or more DOT 3AL cylinders. The reference ring must include artificial notches that simulate neck crack (SLC). The size of artificial notch (depth and length) must be obtained from the EE equipment manufacturer. A certification statement signed by a DWC senior review technologist (SRT) must be available for all EE reference rings at each site where retesting is performed. The certification statement must include a standard reference drawing for each reference ring. The standard reference drawing must include the depth of each notch, diameter and type of DOT 3AL cylinder for which the reference ring is used.

d. System Standardization (Calibration):

(1) Ultrasonic Examination (UE) System Standardization: Prior to retesting each specific cylinder design and type, the UE system must be standardized for testing by using a standard reference. The standard reference must be similar (material of construction, size, wall thickness, etc.) to the identified cylinders to be tested. Standardization of the UE system must be performed by using a relevant reference cylinder that is described in paragraph 7.c. of this special permit. The standardization of the UE system is as follows:

- (i) A reference cylinder with an artificial defect made to represent area corrosion must be placed in the UE system. The UE system must be standardized to indicate rejection for an area equal or greater than the machined surface for the cylinder ( $0.70 \text{ in}^2$ ). Where the wall thickness is reduced below  $t_m$ , a straight ultrasound beam must be used to measure the wall thickness of the machined area.
- (ii) A reference cylinder with a FBH made to represent an isolated pit must be placed in the UE system. The FBH must be detected by a minimum of two shear wave beams that strike the FBH from opposite sides (e.g., the first shear wave direction is from top to bottom of the cylinder and the second shear wave direction is from the bottom to top). The UE gain must be increased until the signal from FBH is maximized at 80 percent of the screen height.
- (iii) A reference cylinder with circumferential notches made to represent line corrosion must be placed in the UE system. Each internal and external

notch must be detected by a minimum of one shear wave beam. The UE gain must be increased until the signal from each notch is maximized at 80 percent of the screen height.

(iv) A reference cylinder with longitudinal notches to represent a longitudinal sidewall crack (LSC) must be placed in the UE system. Each internal and external notch must be detected by a minimum of two shear wave beams that strike the LSC from opposite directions (e.g., the first shear wave direction is clockwise and second shear wave direction is counterclockwise). The UE gain must be increased until the signal from the notch is maximized at 80 percent of the screen height.

(2) Eddy Current Examination (EE) Equipment Standardization: The EE equipment must be standardized for each type of DOT 3AL cylinder, using the standard reference ring that includes simulated neck crack notch. The EE system is considered standardized when the probe is threaded into the mid-length of standardization ring and the sensitivity adjusted to produce a spike that crossed the gate (2 screen high) as it passes over the simulated neck crack notch. The details of the equipment standardization for each type of DOT 3AL cylinder must be obtained from the manufacturer's instruction manual included as part of this standardization procedure.

e. Test Procedures:

(1) During the test, each cylinder must be examined by the standardized (calibrated) UE system using a relevant set-up that is described in paragraph 7.d. of this special permit.

(2) For each cylinder tested, all 5 scan passes must be performed as they are described in paragraph 7.d.

(3) A UE system that is set-up to perform a 5 pass scan may perform a 3 pass scan if the longitudinal and circumferential (clockwise) angle beam scans do not detect a rejectable flaw.

(4) A copy of the operating test procedure (as authorized in writing by the AAHMS) for performing UE, EE and enhanced visual inspection of cylinder necks under the terms of this special permit must be at each facility performing ultrasonic examination. At a minimum, this procedure must include:

(i) A description of the test set-up; test parameters; transducer model number, frequency, and size; transducer assembly used; system standardization procedures and threshold gain used during the test; and other pertinent information.

(ii) Requirement for the equipment standardization to be performed at the end of the test interval (cal-out), after 200 cylinders or four hours, whichever occurs first. This cal-out can be considered the cal-in for the next interval during continuous operation. Cylinders examined during the interval between cal-in and cal-out must be quarantined until an acceptable cal-out has been performed. An acceptable cal-out occurs when the calibration cylinder is examined and all required features are revealed without changing examination settings. If an acceptable cal-out does not occur, if any equipment that affects the UE results are replaced or altered (such as a search unit or coaxial cable etc.) or when a loss of power occurs, all cylinders examined since the last successful calibration must be re-examined. Additionally, standardization of test equipment shall be performed when any of the following occurs: the beginning of each work shift; when the cylinder under test has dimensions that exceed the allowable ranges of the reference cylinder; when there is a change of operator(s); if any equipment that affects the UE results are replaced or altered (such as a search unit or coaxial cable etc.) or when a loss of power occurs; and at the end of each work shift.

(5) A written copy of the most recent approved operating test procedures must be provided to a DOT representative when requested. Any change to the written procedures or in UE or EE equipment (software or hardware), other than as supplied by the original equipment manufacturer, must be submitted to and approved by AAHMS prior to implementation.

(6) The equipment may not allow testing of a cylinder unless the system has been properly standardized (calibrated).

(7) The rotational speed of a reference cylinder must be such that all simulated defects are adequately detected, measured and recorded.

(8) The rotational speed of the cylinder under UE must not exceed the rotational speed used during the standardization.

(9) The pulse rate must be adjusted to ensure a minimum of 10% over-lapped for each helix.

(10) The area of ultrasonic examination (UE) coverage must be 100% of the cylindrical section. The coverage must extend at least three inches into the sidewall-to-base transition taper.

(11) The area of eddy current and enhanced visual examination coverage must be 100% of the threaded neck of the cylinder.

(12) The external surface of the cylinder to be examined must be free of loose material such as scale and dirt.

f. Acceptance/Rejection Criteria:

(1) UE Acceptance/Rejection Criteria: A cylinder must be rejected based on any of the following:

(i) The wall thickness is less than the design minimum wall thickness for the area described in the standardization section herein, paragraph 7.d.

(ii) If any of the flaws such as the isolated pit, circumferential line corrosion or longitudinal sidewall crack (LSC) which meet the rejection criteria and produce a signal with an amplitude which crosses the reference threshold set in the standardization section (paragraph 7.d.).

(2) EE and Enhanced Visual Examination Acceptance/Rejection Criteria of the Neck Crack (Sustain Load Crack):

(i) EE Reject Criteria: One-quarter screen height indications on two consecutive revolutions of the probe at approximately the same bore location are cause for visual follow up inspection for final disposition.

(ii) Enhanced Visual Examination/Verification: Enhanced visual inspection shall be performed before and after eddy current examination or when required by eddy current examination. The inspection is performed with the use of supplemental tools, which typically include an inspection light and mirror. The light is a high intensity type and the mirror a 2-inch diameter 2X dental mirror. Visual Examination Reject Criteria:

(A) Neck Cracks: Cylinders with neck cracks must be condemned. Repair of neck cracks is not allowed.

(B) Folds: Condemn all cylinders with folds that enter into more than one continuous full neck thread.

(C) Valleys: Cylinders with one or more valleys are acceptable for use, provided the valley(s) does not enter into the minimum number of required threads. Seven full threads for tapered threads and six full threads for straight threads.

(D) Threads: Cylinders must be condemned if seven continuous full threads for tapered threads or six continuous full threads for straight threads are not present. A thread shall be considered full if



its root and crest display no significant visual difference to that of the uppermost cylinder thread. Threads that do not meet this criterion are considered to be incomplete or a partial thread.

(E) Tool Stop Mark: A neck with a tool stop mark is to be distinguished from a crack. Cylinders with tool stop marks are acceptable for use.

g. Rejected cylinders: When a cylinder is rejected, the retester must stamp a series of X's over the DOT specification number and marked service pressure, or stamp "CONDEMNED" on the shoulder, top head or neck using a steel stamp, and must notify the cylinder owner, in writing, that the cylinder is rejected and may not be filled with hazardous material for transportation in commerce.

(1) Alternatively, at the direction of the owner, the retester may render the cylinder incapable of holding pressure.

(2) If a condemned cylinder contains hazardous materials and the testing facility does not have the capability of safely removing the hazardous material, the retester must stamp the cylinder "CONDEMNED" and affix conspicuous labels on the cylinder(s) stating: "UE REJECTED DOT-SP 14149. RETURNING TO ORIGIN FOR PROPER DISPOSITION". The retester may only offer the condemned cylinders for transportation by a motor vehicle operated by a private carrier to a facility, identified to, and acknowledged in writing with OHMS that is capable of safely removing the hazardous material. A current copy of this special permit must accompany each shipment of condemned cylinders transported for the disposal of hazardous material.

h. Marking: Each cylinder passing requalification under the provisions of this special permit must be marked as prescribed in accordance with § 180.213. In addition, each cylinder must be marked UE, in characters not less than 1/4" high for a cylinder with a diameter equal to or greater than 4 inches and 1/8" high for a cylinder with a diameter less than 4 inches. DOT 3AL cylinders that were manufactured from AA 6351 and examined by eddy current examination must be marked with UE/EE in characters described herein. The UE/EE may be replaced by UEEE for cylinders with a diameter less than 4 inches. The marking must be at a location close to the retester's marking.

i. UE Report: A report must be generated for each cylinder that is examined. The SRT must prepare and submit the reports required below and annually certify that the UE program is being operated in accordance with the requirements of this special permit. The UE, EE and visual inspection report must include the following:

(1) UE and EE equipment, model and serial number;

- (2) Transducer specification, size, frequency and manufacturer;
  - (3) Specification of each standard reference used to perform UE and EE. UE standard reference must be identified by serial number or other stamped identification marking;
  - (4) Cylinder serial number and type;
  - (5) UE technician's name and certification level;
  - (6) Examination Date;
  - (7) Location and type of each defect on the cylinder (e.g., longitudinal line corrosion 5 inches from base);
  - (8) Dimensions (area, depth and remaining wall thickness) and brief description of each defect;
  - (9) Acceptance/rejection results; and
  - (10) The reports must be on file at each test facility, and copies provided to a DOT official when requested.
- j. Personnel Qualification: Each person who performs retesting, and evaluates and certifies retest results must meet the following qualification requirements:
- (1) Project Manager/Director of Product Technology - is the senior manager of Hexagon Digital Wave LLC responsible for compliance with DOT regulations including this special permit. Additionally, the project manager must ensure that each operator and senior review technologist maintains the required certifications described herein.
  - (2) The personnel responsible for performing cylinder retesting under this special permit must be qualified to an appropriate Ultrasonic Testing Certification Level (Level I, II or III) in accordance with the American Society for Nondestructive Testing (ASNT) Recommended Practice NT-TC-1A depending upon the assigned responsibility as described below:
    - (i) System startup and calibration must be performed by a Level II operator. A Level II operator may review and certify test results. However, written procedures for accepting/rejecting a cylinder must be provided by the senior review technologist. Based upon written criteria, the Level II Operator may authorize cylinders that pass the retest to be marked in accordance with paragraph 7.h. of this special permit. A person with Level

I certification may perform a system startup, check calibration, and perform ultrasonic testing under the direct guidance and supervision of a Senior Review Technologist or a Level II Operator, either of whom must be physically present at the test site so as to be able to observe testing conducted under this special permit.

(ii) Senior Review Technologist (SRT) is a person who provides written UE procedure, supervisory training, examinations (Level I and II) and technical guidance to operators, and reviews and verifies the retest results. The SRT must prepare and submit the reports required in paragraph 7.i. and annually verify that the UE program is being operated in accordance with the requirements of this special permit. An SRT must have a thorough understanding of the DOT Regulations (49 CFR) pertaining to the requalification and reuse of DOT cylinders that are authorized under both this special permit and ASNT Recommended Practice SNT-TC-1A and must possess:

(A) A Level III certification from ASNT in Ultrasonic Testing;  
or

(B) A Professional Engineer (PE) License with a documented experience for a minimum of 2 years of experience in Non-Destructive Evaluation (NDE) of pressure vessels or pipelines using the ultrasonic examination technique; or

(C) A PhD degree in a discipline of Engineering/Physics with documented evidence of experience in Non-Destructive Evaluation (NDE) of pressure vessels or pipelines using the ultrasonic examination technique or research/thesis work and authoring/co-authoring of technical papers published, in recognized technical journals, in the fields of ultrasonic testing methods.

The most recent copies of certification (e.g., ASNT Level III, P.E.) must be available for inspection at each requalification facility.

k. OPERATIONAL CONTROLS:

(1) No person may perform inspection and testing of cylinders subject to this special permit unless:

(i) That person is an employee or agent of Hexagon Digital Wave LLC and has a current copy of this special permit at the location of such inspection and testing; and

(ii) That person complies with all the terms and conditions of this special permit; and

(iii) That person is listed on the Authorized Agent List on file with the Office of Hazardous Materials Safety. The Authorized Agent List must be updated and resubmitted each time a RIN holder is approved to perform inspection and testing in accordance with this special permit or a RIN holder is removed from the Authorized Agent List. Each submission must include the full list of authorized agents.

(2) The marking of the retester's symbol on the cylinders certifies compliance with all of the terms and conditions of this special permit and the HMR.

(3) Each facility approved by OHMS to test cylinders under the terms of this special permit must have a resident operator with at least an ASNT Level II Certification in UT.

(4) The UE and EE equipment and operating procedures identified in this special permit are only authorized for use when the approved SRT is available (or alternatively available by telephone or other electronic means) at each facility operating under the special permit.

(5) Notwithstanding the requirements of a RIN Approval for notification of address and personnel changes, any change in Project manager or SRT, with appropriate documentation (i.e., ANST certification), must be submitted to and acknowledged in writing by OHMS immediately.

8. **SPECIAL PROVISIONS:**

a. The ultrasonic examination (UE) data, results, and additional technical information deemed pertinent in successful application of the UE must be recorded and kept at each facility for a minimum of 5 years after completion of UE. For any rejected cylinder, the defect causing the rejection must be fully characterized and profiled. That is, the specific type of defect should be identified (i.e., isolated pits, line corrosion or SBT crack) and the specific size of the defect should be determined (i.e., length, depth, width, diameter, area, etc.). The record includes cylinder type, size, minimum design wall thickness, age, etc. of the rejected cylinder.

b. Shippers (offerors) may use the cylinders specified and tested in accordance with the provisions of this special permit for the transportation in commerce of those hazardous materials specified herein, provided no modifications or changes are made to the cylinders. All terms of this special permit and other applicable requirements contained in 49 CFR Parts 100-185 must be met.

- c. Transportation of Division 2.1 (flammable gases) and Division 2.3 (gases which are poisonous by inhalation) are not authorized aboard cargo vessel or aircraft unless specifically authorized in the Hazardous Materials Table (§ 172.101).
  - d. Transportation of oxygen is only authorized by aircraft when in accordance with § 175.501.
  - e. Upon approval of this special permit Hexagon Digital Wave LLC may continue to requalify cylinders as described herein. However, PHMSA will visit the Hexagon Digital Wave LLC facility at which time Hexagon Digital Wave LLC must demonstrate that the system performs as stated in the application.
9. MODES OF TRANSPORTATION AUTHORIZED: Motor vehicle, rail freight, cargo vessel, cargo-only aircraft and passenger-carrying aircraft, as currently authorized by the regulations for the hazardous materials being transported.
10. MODAL REQUIREMENTS: None, other than as required by the HMR.
11. COMPLIANCE: Failure by a person to comply with any of the following may result in suspension or revocation of this special permit and penalties prescribed by the Federal hazardous materials transportation law, 49 U.S.C. 5101 et seq:
- o All terms and conditions prescribed in this special permit and the Hazardous Materials Regulations, 49 CFR Parts 171-180.
  - o Persons operating under the terms of this special permit must comply with the security plan requirement in Subpart I of Part 172 of the HMR, when applicable.
  - o Registration required by § 107.601 et seq., when applicable.

Each “Hazmat employee”, as defined in § 171.8, who performs a function subject to this special permit must receive training on the requirements and conditions of this special permit in addition to the training required by §§ 172.700 through 172.704.

No person may use or apply this special permit, including display of its number, when this special permit has expired or is otherwise no longer in effect.

Under Title VII of the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) — “The Hazardous Materials Safety and Security Reauthorization Act of 2005” (Pub. L. 109-59), 119 Stat. 1144 (August 10, 2005), amended the Federal hazardous materials transportation law by changing the term “exemption” to “special permit” and authorizes a special permit to be granted up to two years for new special permits and up to four years for renewals.

12. **REPORTING REQUIREMENTS:** Shipments or operations conducted under this special permit are subject to the Hazardous Materials Incident Reporting requirements specified in 49 CFR §§ 171.15 Immediate notice of certain hazardous materials incidents, and 171.16 Detailed hazardous materials incident reports. In addition, the grantee(s) of this special permit must notify the Associate Administrator for Hazardous Materials Safety, in writing, of any incident involving a package, shipment or operation conducted under terms of this special permit.

Issued in Washington, D.C.:



for William Schoonover  
Associate Administrator for Hazardous Materials Safety

Address all inquiries to: Associate Administrator for Hazardous Materials Safety, Pipeline and Hazardous Material Safety Administration, U.S. Department of Transportation, East Building PHH-13, 1200 New Jersey Avenue, Southeast, Washington, D.C. 20590.

Copies of this special permit may be obtained by accessing the Hazardous Materials Safety Homepage at <https://www.phmsa.dot.gov/approvals-and-permits/hazmat/special-permits-search>. Photo reproductions and legible reductions of this special permit are permitted. Any alteration of this special permit is prohibited.

PO: ae