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Recommended Practice

Pressurized Enclosures

ISA-RP12.4 — Pressurized Enclosures

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Preface

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Contents

1 Scope

1.1 This recommended practice applies to equipment made suitable for use in hazardous (classified) locations by the use of a pressurizing system.

1.2 This recommended practice applies both to equipment with and without an internal release of a flammable gas or vapor.

1.3 This recommended practice does not apply to occupied portions of buildings such as ventilated or pressurized control rooms.

2 Purpose

2.1 This recommended practice provides guidance to those who design and install pressurized systems for hazardous (classified) locations, and should be used in conjunction with ANSI/NFPA 496, Purged and Pressurized Enclosures for Electrical Equipment.

2.2 This recommended practice provides performance and test recommendations so that the enclosure and components mounted internally or protruding through the enclosure are unlikely to cause ignition of a surrounding flammable atmosphere.

2.3 This recommended practice provides performance and test recommendations so that users are unlikely to be injured by rupture of the enclosure due to failure of the pressure-regulating devices in the PROTECTIVE GAS SUPPLY.

3 Definitions

NOTE — The following definitions are in accordance with ISA-S12.1-1991 and ANSI/NFPA 496-1993. Defined terms are shown as SMALL CAPS in the text.

3.1 alarm: A piece of equipment that generates a visual or audible signal that attracts attention.

3.2 flammable (explosive) limits: The flammable (explosive) limits of a gas or vapor are the lower (LFL or LEL) and upper (UFL or UEL) percentages by volume of concentration of gas in a gas-air mixture that will form an ignitable mixture. (Reference ANSI/NFPA 325M.)

3.3 hazardous (classified) location: A location in which fire or explosion hazards may exist due to flammable gases or vapors, flammable liquids, combustible dust, or easily ignitable fibers or flyings.

> **NOTE —** For convenience, the term “hazardous (classified) location” is shortened to “HAZARDOUS LOCATION” throughout this document.

3.4 maximum operating pressure: The maximum internal pressure permitted for an enclosure.

3.5 pressurization: The process of supplying an enclosure with a PROTECTIVE GAS with or without continuous flow at sufficient pressure to prevent the entrance of a flammable gas or vapor, a combustible dust, or an ignitable fiber.

3.6 protective gas: The gas used to maintain PRESSURIZATION or to dilute a flammable gas or vapor.

3.7 protective gas supply: The compressor, blower, or compressed gas container that provides the PROTECTIVE GAS at a positive pressure. The supply includes inlet (suction) pipes or ducts, pressure regulators, outlet pipes or ducts, and any supply valves not adjacent to the pressurized enclosure.

3.8 purging: The process of supplying an enclosure with a PROTECTIVE GAS at a sufficient flow and positive pressure to reduce the concentration of any flammable gas or vapor initially present to an acceptable level.

3.9 routine test: A test that is performed on each piece of equipment during the production process.

3.10 type test: A test that is performed on one or more pieces of equipment, representative of a type, to determine whether the design, construction, and manufacturing methods comply with the requirements according to this recommended practice.

3.11 Type X pressurizing: A type of pressurization that reduces the classification within the protected enclosure from Division 1 to nonclassified.

3.12 Type Y pressurizing: A type of pressurization that reduces the classification within the protected enclosure from Division 1 to Division 2.

3.13 Type Z pressurizing: A type of pressurization that reduces the classification within the protected enclosure from Division 2 to nonclassified.

4 General requirements

4.1 Equipment should be capable of being installed according to the requirements of the applicable national codes.

4.2 Equipment should comply with the applicable general-purpose safety standards — e.g., ANSI/ISA-S82.01, “Safety Standard for Electrical and Electronic Test, Measuring, Controlling, and Related Equipment.” (Additional information is located in Annex B.)

5 Enclosure requirements

5.1 The enclosure should be designed to minimize the flow of PROTECTIVE GAS required to maintain PRESSURIZATION. It is recommended to have a degree of protection of at least IP40 (as described in IEC publication 529) is recommended.

> **NOTE —** Enclosures meeting IP40 do not have openings exceeding 1 mm in diameter. Enclosure ratings of Type 3, 3S, 4, 4X, 5, 6, 12 and 13, (as described in ANSI/NEMA 250, ANSI/UL 50, and CSA C22.2 No. 94) meet this requirement.

5.2 Where ignition-capable particles are created under either normal or single fault condition, openings should comply with Table 1 to prevent ignition-capable particles from exiting the enclosure. (Additional information is located in Annex B.)

> **NOTES**
>
> 1. Ignition-capable particles would not be created under either normal or single fault condition, where the enclosure contains only Class 2 and Class 3 circuits as defined by ANSI/NFPA 70 Article 725.
> 2. Ignition-capable particles would not be created under either normal or single fault condition, where no ignition-capable particles or flames are created when the equipment is tested per Clause 4.4 of ANSI/ISA-S82.01-1994.

Table 1 — Clauses relevant to enclosure openings

Location of opening	Clauses applicable to an enclosure suitable for Division 2 Locations		Clauses applicable to an enclosure suitable for Division 1 Locations
	Ignition-capable particles are created under		Ignition-capable particles are created under normal or single fault conditions
	single fault condition	normal condition	
Around components that protrude through the enclosure	N.R.	5.2.1	5.2.1
Pressure relief vents	N.R.	N.R.	5.2.2
Continuous vents	N.R.	5.2.2	5.2.2

N.R. = no requirement

5.2.1 Openings should be protected to prevent the release of ignition-capable particles by one of the following methods:

a) Provide a suitable partition between the source of the ignition-capable particles and a through-the-enclosure component;

b) Provide an operating shaft with a bushing that is 0.5 in. (12.7 mm)or longer and the opening between the bushing and the operating shaft is less than 0.005 in. (0.13 mm); or

c) Provide a bezel around a through-the-enclosure component to reduce the opening to less than 0.005 in. (0.13 mm).

5.2.2 Vents should be protected to prevent the release of ignition-capable particles by one of the following methods:

a) Provide the vent with a hub (so that it may be used with pipes or ducts that exhaust into a nonclassified location);

b) Provide suitable baffles to deflect any particles away from the vent; or

c) Provide the vent with a substantially noncombustible screen or filter.

NOTE — Materials rated as 94 V-0 or 94 5V (as described in ANSI/UL 94 and CSA C22.2 No. 0.6) are considered as substantially noncombustible.

CAUTION — PROVIDING A SCREEN OR FILTER MAY REDUCE VENTING CAPACITY AND MAY REQUIRE A DESIGN WITH A LARGER VENT.

6 Components that protrude through the enclosure

6.1 Components should permit the flow of the PROTECTIVE GAS to properly purge and pressurize the component. (Additional information is located in Annex B.)

EXCEPTION: Components that are suitable for the HAZARDOUS LOCATION and that would exist in the absence of the PROTECTIVE GAS do not require purging or pressurizing.

7 Protecting hot surfaces and ignition-capable components

7.1 Electrical components mounted internally and electrical components mounted through the enclosure should be adequately protected so that likely failure or abuse will not expose a hot surface or an ignition-capable arc to the external flammable atmosphere. (Additional information is located in Annex B.)

NOTES

1) Ignition-capable arcs can occur either during normal operation or as a temporary arc occurring as a result of the likely failure or abuse.

2) Ignition by a hot surface is discussed in NFPA 496 Clause 2-5.1.

EXCEPTION: Equipment that (1) does not normally create ignition-capable particles, (2) is for use in Class I, Division 2 HAZARDOUS LOCATIONS, and (3) has an ALARM to notify the user when PRESSURIZATION fails does not require further protection.

7.2 The enclosure, external components, and nonmetallic parts of the enclosure that protect internal components should not be damaged when exposed to the impact levels in Table 2. Parts that can be removed without the use of a tool are to be removed before testing.

Table 2 — Impact levels for enclosure parts

Type of Part	Impact Energy (joules)	Drop Height Factor (meters-kg)
Light-transmitting parts with guard (tested without guard)	2	0.204
Light-transmitting parts not guarded	4	0.408
Other parts of enclosure	7	0.714

Compliance is verified by subjecting the electrical apparatus to the effect of a test mass falling vertically from a drop height (h). The drop height (h), in meters, is determined by dividing the value shown in the drop height factor column by the mass of the test mass in kilograms. The impact head of the test mass should be a 25 mm (1 in.) diameter hardened steel hemisphere. Components fail the test if hot surfaces or arcing contacts are exposed or if an ignition-capable arc occurs. Enclosures fail if hot surfaces or arcing contacts are exposed.

8 Protecting against enclosure rupture

8.1 Failure of the PROTECTIVE GAS SUPPLY pressure regulator could result in flying fragments from the enclosure. Personnel should be protected from injury by either of the following methods:

a) The inlet should be restricted by either the supply connector size or by an additional orifice such that the leakage openings in the enclosure and any pressure relief devices will be able to prevent the internal pressure from exceeding the rated MAXIMUM OPERATING PRESSURE, verified by the test in 10.1 and 10.2; or

EXCEPTION: The test in 10.1 may be replaced by a calculation of the relief valve size for the enclosure based upon the MAXIMUM OPERATING PRESSURE, the inlet size, the pressure relief outlet size and pressure relief operating point.

b) Instructions should require the user to limit the pressure as specified in 8.3.

8.2 High internal pressures can cause doors or covers to open violently. Personnel should be protected from injury by methods such as the following:

a) Use of multiple fasteners so that the enclosure will safely vent before all fasteners are released;

b) Use of a two-position fastener to allow safe venting of the pressure when opening the enclosure; or

c) Limiting the maximum internal pressure to not greater than 10 in. H_2O (2.5 kPa).

8.3 When instructions require the user to limit the pressure, the MAXIMUM OPERATING PRESSURE should be marked on the enclosure, and the instructions should contain either of the following:

a) Requirements for the user to install a PROTECTIVE GAS SUPPLY that will not exceed the MAXIMUM OPERATING PRESSURE of the enclosure under single-fault conditions. The fault should be self-revealing. Protection can be either with a redundant regulator or with an external pressure relief valve that is capable of handling the maximum flow rate; or

b) Requirements for the user to use only a blower system and not compressed air for the PROTECTIVE GAS SUPPLY.

Compliance is checked by inspection of the instructions and markings.

9 PURGING requirements

Airflow through the enclosure during PURGING should be designed to avoid air pockets. Air pockets can be avoided by properly locating the PROTECTIVE GAS SUPPLY inlet and outlet and by minimizing the effect of partitions as follows:

9.1 For gases or vapors that are heavier-than-air (i.e., with a specific density greater than 1.0), the inlet for the PROTECTIVE GAS should be near the top of the enclosure, and the outlet near the bottom of the enclosure.

9.2 For gases or vapors that are lighter-than-air (i.e., with a specific density less than 1.0), the inlet for the PROTECTIVE GAS should be near the bottom of the enclosure, and the outlet near the top of the enclosure.

NOTES

1) The specific densities of many gases and vapors are specified in ANSI/NFPA 325M, Fire Hazard Properties of Flammable Liquids, Gases, and Volatile Solids.

2) Locating inlets and outlets at opposite sides of the enclosure promotes cross ventilation.

9.3 Internal partitions (e.g., circuit boards) should not obstruct the flow of PROTECTIVE GAS. Where the flow is significantly obstructed, either

a) the PROTECTIVE GAS should be directed by baffles or a manifold, or

b) the enclosure should pass the PURGING test described in 10.3.

10 Tests

10.1 Verifying ability of enclosure to limit internal pressure

This test is applicable where required by 8.1 (i.e., where an enclosure is designed for use with compressed air or other compressed gas) and where leakage, vents, or pressure relief devices are relied upon to limit the maximum internal pressure.

WARNING — THE FOLLOWING TESTS CAN BE INHERENTLY DANGEROUS UNLESS ADEQUATE SAFEGUARDS FOR PERSONNEL AND PROPERTY ARE EMPLOYED .

10.1.1 The enclosure should be tested with 100 psi (690 kPa) applied to the PROTECTIVE GAS SUPPLY inlet.

NOTE — The inlet includes any restricted tubing or orifices that are part of the PROTECTIVE GAS SUPPLY. The regulators in the PROTECTIVE GAS SUPPLY should be disabled.

10.1.2 If there is an internal release, the flow rate into the enclosure should be increased by an amount equal to the maximum rated flow of the internal release.

10.1.3 The tested sample should have a leakage rate that is representative of the tightest sealing expected for the enclosure. This can be accomplished by the addition of sealing material to make the unit representative of the likely manufacturing tolerances.

10.1.4 All openings that can be closed during normal operation of the equipment should be closed.

10.1.5 The measured internal pressure should not exceed the specified MAXIMUM OPERATING PRESSURE.

10.2 MAXIMUM OPERATING PRESSURE TEST

This test is applicable when required by 8.1.

10.2.1 A sample enclosure should be TYPE TESTED or all enclosures should be ROUTINE TESTED to verify they will not catastrophically fail when subjected to the MAXIMUM OPERATING PRESSURE.

10.2.2 The enclosure should be tested using either of the following:

a) TYPE TESTED at 3 times the rated MAXIMUM OPERATING PRESSURE for a minimum of 60 seconds; or

b) ROUTINE TESTED at 1.5 times the rated MAXIMUM OPERATING PRESSURE or 0.8 in H_2O (0.2 kPa), whichever is greater, for a minimum of 10 seconds.

10.2.3 The enclosure should not fail in a manner that creates flying fragments.

10.2.4 Deformation of the enclosure during the TYPE TEST, whether permanent or not, is permitted; however, the deformation should be repeatable and not just a deformation unique to the one sample tested; e.g., a manufacturing defect in that sample. If in doubt about whether the deformation is unique to that sample, a second sample should be tested.

10.3 PURGING test

The following procedure should be used when required by 9.3.

10.3.1 The enclosure should be fitted with a number of small bore tubes, the open ends of which should be located inside the enclosure at sampling points where it is considered that the test gas is most likely to persist during the tests.

10.3.2 If necessary, operational openings in the pressurized enclosure may be closed to enable the enclosure to be filled with the specified test gas, provided that they are reopened when the PROTECTIVE GAS SUPPLY is turned on.

10.3.3 The enclosure should be filled with the test gas to a concentration of not less than 70 percent by volume at any point. When the PROTECTIVE GAS is air and when all permissible flammable gases are to be covered by the test, two tests should be performed — one with helium to represent lighter-than-air gases and a second with either argon or carbon dioxide to represent heavier-than-air gases.

NOTE — It is preferable to use test gas mixtures that are both nonflammable and nontoxic.

10.3.4 As soon as the enclosure is filled, the test gas supply should be turned off, and the PROTECTIVE GAS SUPPLY should be turned on at the minimum purge rate and for the minimum purge time specified by the manufacturer. At the end of the purge time, the mixture(s) collected from the small bore tubes should not exceed the following applicable limits:

a) 1 percent by volume for the helium test and 0.25 percent by volume for the argon or carbon dioxide test;

b) A concentration equivalent to 25 percent of the most onerous LEL where two tests are performed to cover a specific range of flammable gases; or

c) A concentration equivalent to 25 percent of the LEL where one specific flammable gas is covered.

10.3.5 When a PROTECTIVE GAS other than air is used, the concentration of oxygen after PURGING should not exceed 2 percent by volume.

11 Marking

11.1 In addition to the marking requirements of ANSI/NFPA 496, the following should be included:

a) the minimum and MAXIMUM OPERATING PRESSURE of the enclosure, and

b) the type of PROTECTIVE GAS (if not air).

12 Enclosure access for maintenance

12.1 Any enclosure interlock bypass switch used to facilitate maintenance should be self-resetting and require a tool to actuate or a tool should be required to gain access to the switch.

EXCEPTION: The switch does not need to be self-resetting if an ALARM is used to indicate that the enclosure interlock switch has been bypassed.

12.2 For TYPE X PRESSURIZING, a time delay of 30 seconds or less may be used to facilitate opening the door and actuating the enclosure interlock bypass switch. Upon loss of pressure, an ALARM should be energized immediately, but the de-energizing of circuits may be delayed. If any part of the enclosure can be readily opened without the use of a key or tool, opening such part shall immediately result in de-energizing all circuits not approved for Division 1 locations, as required by ANSI/NFPA 496 3-5.2.

Annex A — (normative) References

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ANSI/ASME B36.10	Welded and Seamless Wrought Steel Pipe
Available from:	**ASME** 345 E. 47th Street New York, NY 10017 Tel: (212) 705-7722

CANADIAN STANDARDS ASSOCIATION (CSA)

C22.2 No. 0.6	Flammability Testing of Polymeric Materials
C22.2 No. 94	Special Purpose Enclosures
Available from:	**CSA** 178 Rexdale Blvd. Etobicoke, Ontario M9W 1R3 Canada Tel: (416) 747-4044

INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)

IEC 529	Degrees of Protection Provided by Enclosures, (IP Code)
Available from:	**American National Standards Institute (ANSI)** 11 West 42nd Street New York, NY 10036 Tel: (212) 642-4900

THE INTERNATIONAL SOCIETY FOR MEASUREMENT & CONTROL (ISA)

ISA-S12.1	Definitions and Information Pertaining to Electrical Instruments in Hazardous (Classified) Locations
ANSI/ISA-S82.01	Safety Standard for Electrical and Electronic Test, Measuring, Controlling, and Related Equipment - General Requirements
Available from:	**ISA** 67 Alexander Drive P.O. Box 12277 Research Triangle Park, NC 27709 Tel: (919) 990-9200

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI/NEMA 250	Enclosures for Electrical Equipment (1000 Volts Maximum)
Available from:	**NEMA** 1300 North 17th Street, Suite 1847 Rosslyn, VA 22209 Tel: (703) 841-3200

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

ANSI/NFPA 325M	Properties of Flammable Liquids
ANSI/NFPA 496	Purged and Pressurized Enclosures for Electrical Equipment
Available from:	**NFPA** Batterymarch Park Quincy, MA 02269 Tel: (617) 770-3000

UNDERWRITERS LABORATORIES, INC. (UL)

ANSI/UL 50	Enclosures for Electrical Equipment
ANSI/UL 94	Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
Available from:	**UL** 333 Pfingsten Road Northbrook, IL 60062 Tel: (708) 272-8800

NOTE — Any undated reference to a code or standard appearing in this recommended practice shall be interpreted as referring to the latest edition of that code or standard.

Annex B — (informative) Comments on the text

Please refer to the following referenced clauses in the main body of the text:

B 4.2 Equipment enclosures should provide protection to prevent deterioration that would adversely affect the suitability of the equipment for use in the HAZARDOUS LOCATION. Although general-purpose enclosures will normally suffice, particular attention should be given to the possible need for weatherproofing and general protection from corrosion and cleaning procedures. The materials used for the enclosure should not be adversely affected by the specified PROTECTIVE GAS nor by the flammable gases or vapors in which they are to be used.

B 5.2 Ignition-capable particles are created abnormally by failure of electrical components (e.g., electrolytic capacitors and transformers) in supply circuits. Ignition-capable particles are created normally by mechanisms (e.g., motor starter contacts) switching high power circuits.

Additional information on single fault conditions may be found in electrical safety standards such as ANSI/ISA-S82.01-1994.

The practice of sealing openings in Type 1 enclosures (as described in NEMA 250) using materials such as silicone or latex caulking or polyurethane or rubber sealing strips is acceptable for Division 2 HAZARDOUS LOCATIONS, but not for Division 1 HAZARDOUS LOCATIONS unless it is unlikely that ignition-capable particles could escape the enclosure if those materials were to fail.

B 6 This requirement is intended for components such as switches, keyboards, lamps, and indicators, and for mechanical devices such as shafts that penetrate the enclosure.

B 6.1 Methods of protection to comply with the *Exception* include mounting the component in an explosionproof housing or using the component in an intrinsically safe circuit. For Division 2 applications, exceptions include a nonincendive component or a component used in a nonincendive circuit.

B 7.1 Pressurized enclosures will normally be robustly designed and unlikely to fail. However, PRESSURIZATION is frequently the only method of protecting equipment not initially designed for use in a HAZARDOUS LOCATION. The enclosure of such equipment may be more likely to fail the impact tests. The use of such equipment is permitted only in a Division 2 HAZARDOUS LOCATION and it should have an ALARM to immediately notify when PRESSURIZATION fails.

Annex C — (informative) Information for sizing pipes and ducts

The flow of PROTECTIVE GAS through pipes and ducts results in a pressure drop. If the pipe or duct is too small, the pressure drop may be so large that it will be impossible to obtain the desired flow rate for PURGING the enclosure within a reasonable time. Also, if the pipe or duct is too small, the velocity of PROTECTIVE GAS may create undesirable noise.

The following provides guidance for sizing the pipe or duct. In general, the term duct applies to blower systems and the term pipe applies to tubing or pipe used in a compressed gas system.

To calculate the pipe or duct size, it is necessary to know the following:

a) V = enclosure volume (in cubic feet);

b) t = the desired purge time, generally 5 to 10 minutes;

c) p = the minimum pressure for the PROTECTIVE GAS SUPPLY in inches of water for blower systems (in psi for compressed air systems);

d) l = the length of the pipe or duct (in feet); and

Items (a) and (b) are then used to calculate the purge rate (R_p):

e) $R_p = V/t$ (cubic feet per minute, CFM).

Table C.1 is used to select the pipe size for a compressed gas system operating at 35 psi.

Table C.2 is used to select the pipe size for a compressed gas system operating at 65 psi.

Table C.3 is used to select the duct size for a blower system operating at 6 in. H_2O.

These tables are meant to provide relative guidelines for sizing piping or duct based upon the required flow rate and the distance between the enclosure being pressurized and the supply source. Other factors may influence the selection of the piping or ductwork — for example, size available and the desire to standardize on one size of pipe. Tables C.1 and C.2 are based on schedule 40 pipe (e.g., ANSI/ASME B36.10) with the following internal diameters:

Pipe Size	1/8	1/4	3/8	1/2	3/4	1
Inside Diameter (inches)	0.269	0.364	0.493	0.622	0.824	1.049
Inside Cross Sectional Area (square inches)	0.057	0.104	0.191	0.304	0.533	0.864

Adjustments will be required when using piping or tubing with a different internal diameter or different internal surface roughness. The use of elbows, “T”s, and reducers also affects pressure drops, but will not normally affect the guidelines provided in the Tables.

Table C.1 — Pipe size as a function of flow and distance with a nominal 35 psi pressure source

Tabulation of minimum pipe/tubing (Schedule 40 pipe size) versus flow rate (in CFM) and length of run (in feet) for a nominal 35 psi pressure source									
CFM	**1’**	**2’**	**5’**	**10’**	**20’**	**50’**	**100’**	**200’**	**500’**
1	1/8								
2									
5	1/8								1/4
10	1/8						1/4		3/8
20	1/8				1/4		3/8		1/2
50	1/8		1/4		3/8		1/2		3/4
100	1/4		3/8		1/2		3/4		1
200	3/8		1/2		3/4		1		
500	1/2		3/4		1				
1000	3/4		1						
2000	1								
5000									

Table C.2 — Pipe size as a function of flow and distance with a nominal 65 psi pressure source

Tabulation of minimum pipe/tubing (Schedule 40 pipe size) versus flow rate (in CFM) and length of run (in feet) for a nominal 65 psi pressure source									
CFM	**1’**	**2’**	**5’**	**10’**	**20’**	**50’**	**100’**	**200’**	**500’**
1	1/8								
2									
5									
10	1/8							1/4	
20	1/8					1/4		3/8	
50	1/8			1/4		3/8		1/2	
100	1/8	1/4		3/8		1/2		3/4	
200	1/4		3/8		1/2	3/4		1	
500	3/8		1/2	3/4					
1000	1/2		3/4	1					
2000	3/4		1						
5000	1								

Table C.3 — Duct size (diameter in inches) as a function of flow and distance with 6 in. H_2O pressure source

Tabulation of minimum duct size (inches diameter) versus flow rate (in CFM) and length of run (in feet) for a nominal 6 in. H_2O pressure source

CFM	1’	2’	5’	10’	20’	50’	100’	200’	500’
100	2					3			4
200	2			3			4		5
500	2	3			4		5	6	7
1000	3		4		5	6	7		8
2000	4		5		6	7	8	9	12
5000	5	6	7		9	10	12	14	
10000	5	7	8	9	12	14			

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