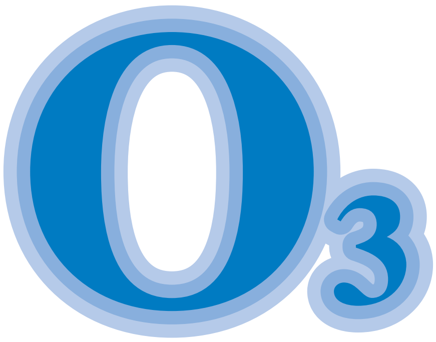
P-E00-6A

SMC

Ozone Resistant Pneumatic Equipment

(The use of pneumatic equipment in low ozone concentration environments)



SMC Corporation

Table of Contents

1. Pneumatic Equipment Malfunctions Caused by Ozone

• Types of Malfunctions Caused by Ozone

Ozone can cause rubber materials (mostly NBR) used in pneumatic equipment to crack, and thereby lead to air leakage and malfunction.

Types of damage and malfunctions

Devices	Damaged parts	Results
Regulator	Diaphragm Photo 1	• Constant air leakage from bleed hole • Unable to adjust pressure
	Main valve seat	• Constant air leakage from bleed hole • Unable to adjust pressure
Speed control valve	Valve seat rubber for check valve Check valve seal Photo 2	• Unable to adjust pressure
Solenoid valve	Main valve seal Photo 3	• Air leakage, Malfunction
	Gasket	• Air leakage, Malfunction
Cylinder (Actuator)	Seals are coated with a lubricant that has a shielding effect from ozone. Damage does not occur. For cylinders lubricated by a compressed air system lubricator, the oil film that is provided to components in this way is equivalent to a grease coat in its protective effects. Even with non-lube type cylinders, grease protects seals from being damaged. (Refer to Grease Coat Protection Effect on page 4.)	

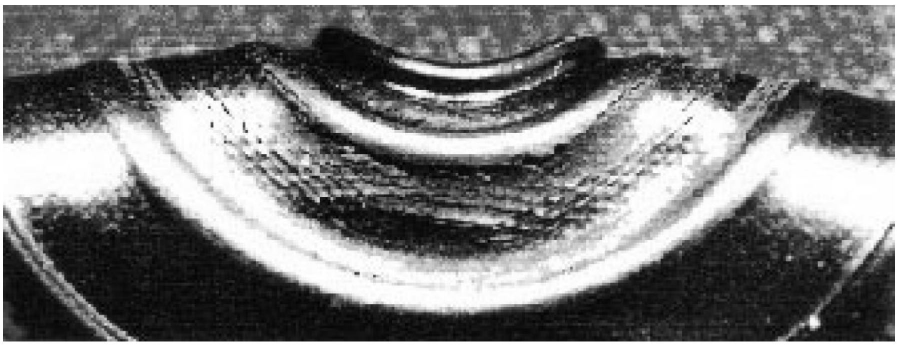


Photo 1 Cracking of diaphragm

Photo 2 Cracking of check valve seal

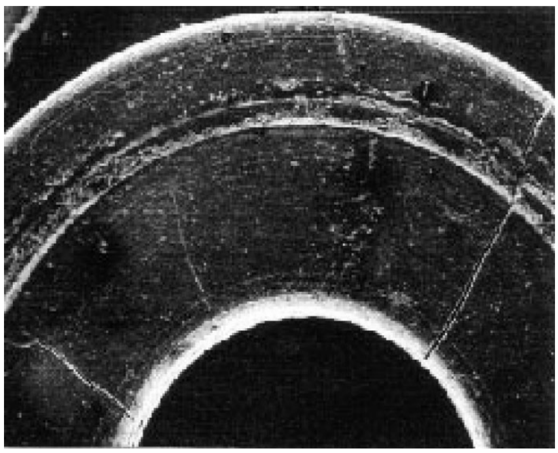


Photo 3 Cracking of main valve seal

• Ozone Concentration and the Time It Takes for Ozone to Generate Cracks (Deterioration) on Rubber

In most cases, there is a clear-cut relationship between ozone concentration (C) and the time it takes for ozone to generate cracks (τ)*.

$$\tau \cdot C^n = \text{Const.}$$

τ: Time it takes for ozone to generate cracks (h)
C: Ozone concentration (ppm)
n: Constant that varies depending on the rubber material

Take the logarithm and rearrange the above equation as follows:

$$\log\tau = K - n \log C$$

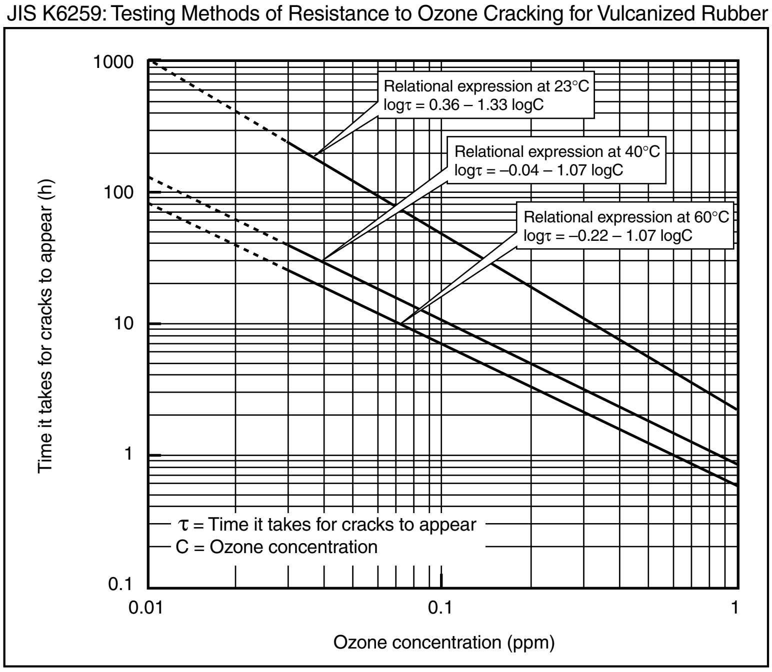
K: Constant

* YU.S Zuev and S.I. Pravednikova "Rubber Chemistry and Technology" (1962) Page 411 to 420

Linear relationships were obtained when plotting the logarithms of the experiments SMC conducted on ozone concentration and the time it takes for ozone to generate cracks. What became evident is that as ozone concentration increases, the time it takes for ozone to generate cracks decreases. These tests were conducted under conditions that are much more severe than those of a normal operating environment, and were likewise evaluated more stringently. The solid lines in the graph indicate actual measurements gathered during the tests, and the dotted lines are estimated values obtained from calculations. Changes in ozone concentration greatly affect the time it takes for ozone to generate cracks.

Ozone concentration and its direct relation to the appearance of cracks (time factor) (NBR)

JIS K6259: Testing Methods of Resistance to Ozone Cracking for Vulcanized Rubber



<Test conditions>
Specimen: I-shaped dumbbell
Tensile strain: 20 ± 2%
Evaluation: Cracking detection using a magnified 50x metallurgical microscope

• Basic Structure and Ozone Resistance

Molecular structure

Ozone resistance of NBR and HNBR varies depending on its structure.

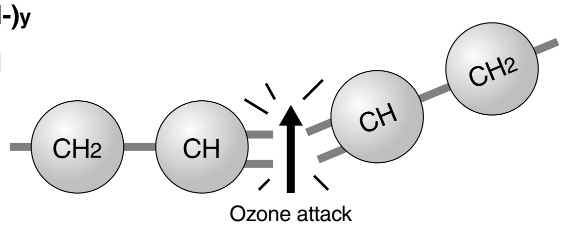
Basic molecular structures

Rubber type	Basic molecular structure
NBR (acrylonitrile-butadiene rubber)	$(-CH_2-CH=CH-CH_2-)_x - (-CH_2-\underset{CN}{CH}-)_y$
HNBR (hydrogenated nitrile butadiene rubber)	$(-CH_2-CH_2-CH_2-CH_2-)_x - (-CH_2-\underset{CN}{CH}-)_y$

Double bond

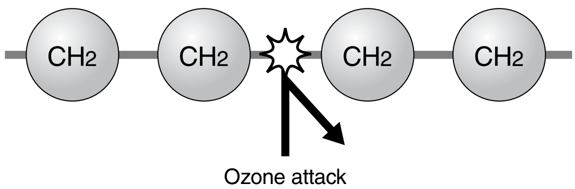
Deterioration caused by ozone occurs when ozone acts on the NBR double bond to break the rubber molecules apart.

NBR $(-CH_2-\underbrace{CH=CH}_{\text{Double bond}}-CH_2-)_x - (-CH_2-\underset{CN}{CH}-)_y$



On the other hand, HNBR's basic structure, which is becoming more and more standard, eliminates the double bond of NBR by adding hydrogen. Although a minute amount of double bond remains in the structure of HNBR to allow it to maintain its physicality as a rubber, its structure has an excellent ozone resistance.

HNBR $(-CH_2-CH_2-CH_2-CH_2-)_x - (-CH_2-\underset{CN}{CH}-)_y$



Ozone resistance

An experiment was performed under test conditions conforming to JIS K6259, and using air containing 1 ppm of ozone. The test conditions (ozone concentration, temperature, and tensile strain) were much more severe than those in a normal operating environment; therefore, cracks were evident in NBR in just 1 to 25 hours of exposure to ozonic air. On the other hand, when the same stringent conditions were applied to HNBR, cracks did not appear even after 1000 hours of exposure.

Ozone resistance

Rubber type	Time it takes for ozone to generate cracks
NBR	1 to 25 hrs.
HNBR	1000 hrs. or more

<Test conditions>
Ozone concentration: 1 ppm
Specimen: I-shaped dumbbell
Tensile strain: 20 ± 2%
Testing temperature: 40 ± 1°C

• Grease Coat Protection Effect

A coating of grease or other lubricants is an effective way to shield NBR parts from ozone attack. When the protective effects of grease were tested and measured, it was found that cracks began to appear after 1 to 25 hours of ozone exposure on NBR components that had not been given a grease coating. On the other hand, cracks did not appear on the components that had received a grease coating, even after more than 1000 hours of ozone exposure. The reasons given for these results are the physical shielding effects of grease, as well as its chemical effects as it reacts to ozone and accelerates its decomposition.

Therefore, no ozone generated cracks were found on components whose seals or seal surfaces are normally treated with a coat of grease (lubricant), e.g., cylinders, rotary actuators, or quick disconnect release couplings (One-touch fittings).

Grease coat protection effect

JIS K6259: Testing Methods of Resistance to Ozone Cracking for Vulcanized Rubber

	Time it takes for ozone to generate cracks
Uncoated NBR	1 to 25 hrs.
Grease coated NBR	1000 hrs. or more

<Test conditions>
Ozone concentration: 1 ppm
Specimen: I-shaped dumbbell
Tensile strain: 20 ± 2%
Testing temperature: 40 ± 1°C
Amount of grease applied: 6.3 mg/cm²

3. The Deteriorating Effect of Ozone

• Causes and Progression of Deterioration due to Ozone

How ozone gets into a pneumatic system

From measurements taken to date, we know with certainty that the concentration of ozone in the air that a pneumatic system compressor takes in is at most 0.1 ppm at a standard atmospheric pressure rating. Factory machinery and equipment are primary sources of ozone. Nevertheless, ozone can also be found in nature along with photochemical oxidants. (Refer to page 11 for details.)

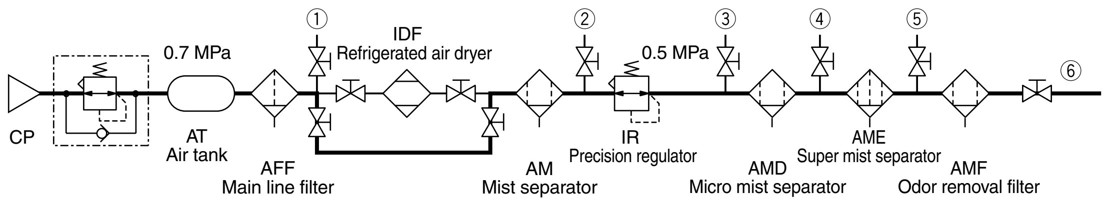
When compressed air containing ozone (possibly generated from other machinery and equipment present in a plant) enters a pneumatic system, it adversely affects the system's rubber components. Besides the more commonly recognized sources of ozone described under "Ozone Emitting Equipment and Devices" on page 8, an air compressor motor that is not maintained and serviced at the proper scheduled intervals can also become a source of ozone emissions.

Traditionally, lube type reciprocating compressors have been widely used in pneumatic systems. Through the use of these ozone-efficient compressors, the amount of ozone in a pneumatic system could be reduced, and its effects in lines nullified, by the heat produced during compression and by the action of draining condensate out of the system. In recent years, however, the widespread use of non-lube type turbocompressors and displacement compressors (dry rotary type) has decreased the chances for ozone depletion in lines.

• Fluctuations to Ozone Concentration in Pneumatic Circuits

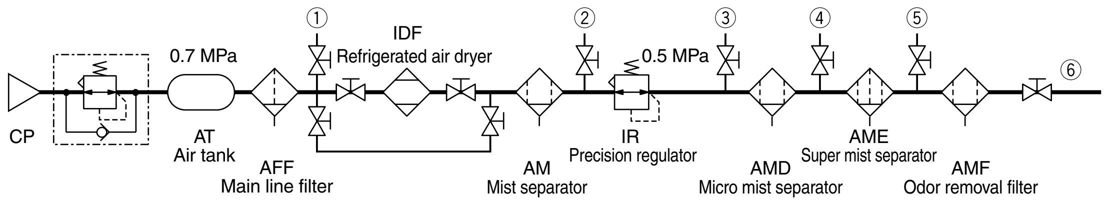
An ozonizer was used to prepare air with ozone concentration rates of 1.1 ppm and 0.1 ppm. The air was introduced into the lines in the system through the compressor's intake port, and measurements were taken of changes in the concentration of ozone after the air passed through the various filters, dryers, and regulators. Since it is extremely difficult to measure the ozone concentration in pressurized air while it is in lines, samplings of pressurized air were taken from certain points in the pneumatic circuit (see ① to ⑥ below) and the ozone concentration was measured immediately, using an ultraviolet absorbent densitometer (EG-2001F made by EBARA JITSUGYO CO., LTD).

Pneumatic circuitry at an atmospheric dew point of 10°C (Circuit not passing through refrigerated air dryer)



∗ The bold line is the testing circuit.

Pneumatic circuitry at an atmospheric dew point of –17°C (Circuit passing through refrigerated air dryer)



∗ The bold line is the testing circuit.

The residual ozone ratio in pneumatic lines

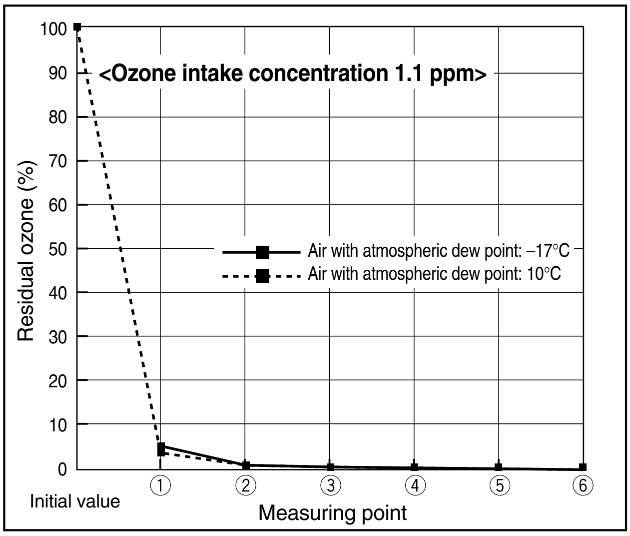
In the lines of lube-type reciprocating compressor, with intake air containing a concentration of 1.1 ppm of ozone, the ozone is phased out as follows:

- Some 95% or more of the ozone is eliminated as air passes through the main line filter (AFF) — as measured at point ① which is just downstream of the AFF in the circuit.
- Most of the remainder is eliminated as air passes through the refrigerated air dryer (IDF) and mist separator (AM) — as measured at point ②, just downstream of these components in the circuit.

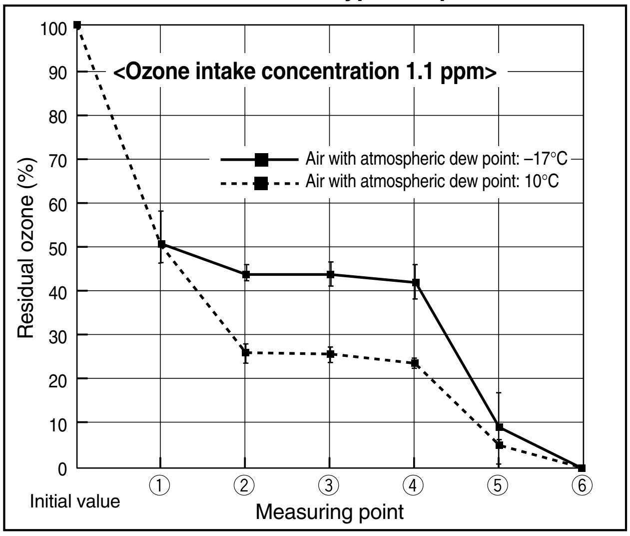
Ozone depletion is much slower in a non-lube scroll type compressor than in a lube type reciprocating compressor. At the same ozone concentration of 1.1 ppm, approximately 25% of the ozone still remains in the circuit as measured at point ② — downstream of the mist separator (AM) — at an atmospheric dew point of 10°C. When the atmospheric dew point is –17°C, approximately 45% of the ozone still remains. Furthermore, with an ozone concentration as low as 0.1 ppm in intake air, fast ozone depletion is evident just until after air passes through the main line filter (AFF) — as measured at point ① in the circuit. After that point, however, ozone depletion is as slow as if the concentration were greater — i.e., as if it were an original concentration of 1.1 ppm. Even after the air has passed through the micromist separator (AMD), a very small residual quantity can still be found in lines at point ④, just downstream.

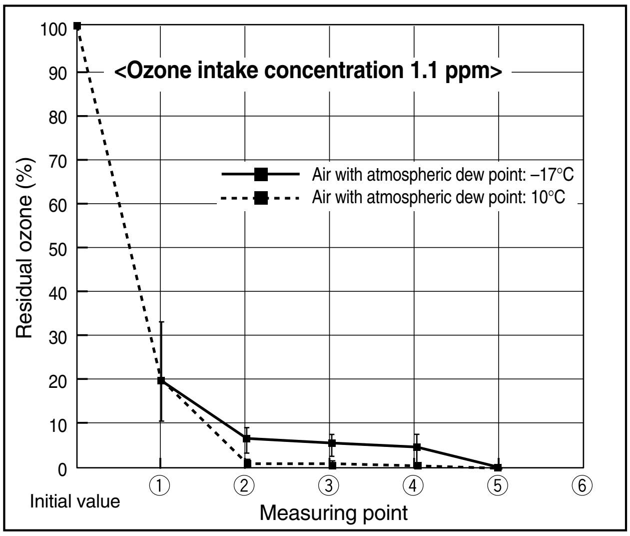
These observations illustrate that the use of so-called "oil-free" air sources and compressed air at low dew points make it difficult to eliminate ozone in pneumatic lines.

The residual ozone ratio in the lines of lube type reciprocating compressor



Changes in the residual ozone ratio in the lines of non-lube scroll type compressor





4. Ozone Resistance of Standard (HNBR) Products

• Setting

Even when ozone is present in compressed air, its concentration is depleted as it travels through the lines in a pneumatic circuit. (Refer to "Fluctuations in the Concentration of Ozone within a Pneumatic System" on page 5.) However, the ratio of ozone depletion, and the harm that residual ozone can cause to pneumatic circuitry, varies according to the equipment and components that are implemented in the particular pneumatic circuit. NBR, for example, is a material that can suffer deterioration caused by residual ozone.

Evaluation criteria for ozone resistance

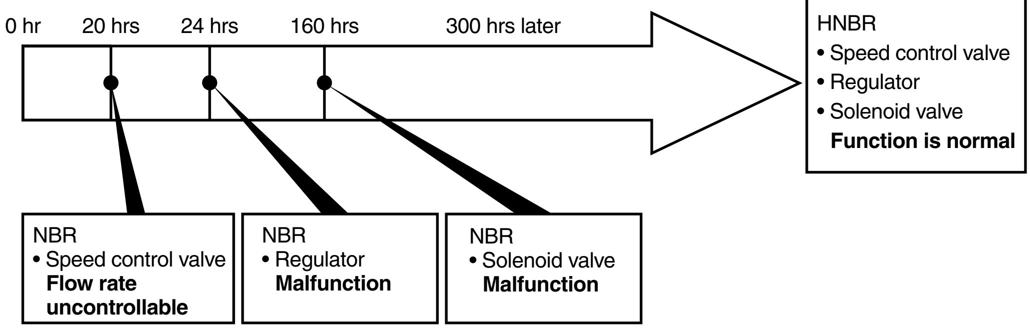
SMC's evaluation criteria for ozone resistance in its products can be defined as follows:
Products meeting a 5-year (or 43,800 hours) resistance rating (or equivalent) under working conditions that include 40°C ambient and fluid temperatures and an ozone concentration of 0.03 ppm in 0.5 MPa compressed air. These standards assume the normal concentration of ozone usually found in the atmosphere, and the ozone depletion that takes place in a pneumatic circuit, but allow for wide tolerance margins in product design.
Please refer to the "List of Ozone Resistant Products 1: Standard (HNBR)" on page 9 to familiarize yourself with standard products using HNBR.
For non-HNBR devices that nevertheless afford superior ozone protection, please refer to the "List of Ozone Resistant Products 2: Series 80-" on page 10.

• Endurance Test

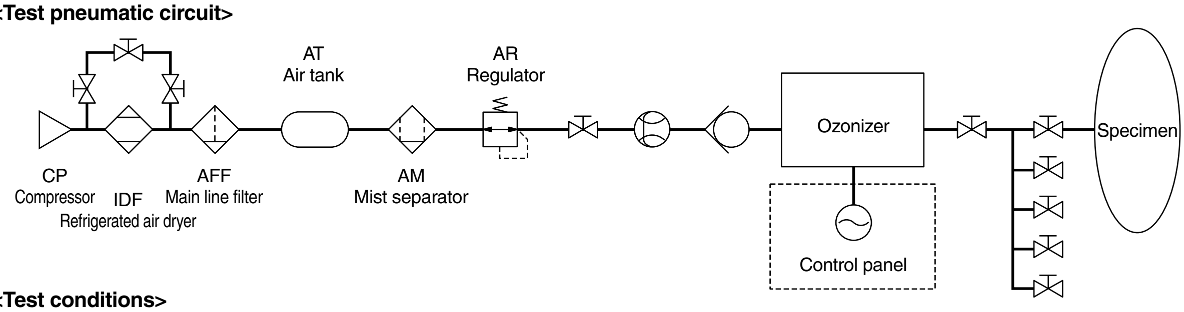
An ozonizer was used in a pneumatic circuit to prepare air to an ozone concentration of 1 ppm. The test specimens (system components made from HNBR and NBR) were operated using this ozone-laden compressed air, and the endurance of each type of component/material was measured and compared.

Endurance test: Speed control valve, regulator, solenoid valve

<Endurance test results>



<Test pneumatic circuit>



<Test conditions>

Models			Ozone resistance evaluation	
			Conditions	Operating frequency
Speed control valve	Series AS-F AS1000, 1400 AS12□0 to AS42□0	NBR	Ozone concentration: 1 ppm Inlet pressure: 0.7 MPa Set pressure: 0.5 MPa Ambient temperature: 23°C	ON 0.5 sec OFF 0.5 sec
		HNBR		
Regulator	AR1000 to 6000	NBR		
	AW1000 to 4000	HNBR		
Solenoid valve	VQ1201H-5	NBR		1Hz
		HNBR		

Line: Polyurethane tube (TU0604); Fitting: Quick disconnect release coupling (One-touch fitting KQ2)

5. Ozone

• What is Ozone?

Ozone is an allotrope of oxygen, and small quantities of it are present in air. It is formed by electrical discharges in dry gaseous oxygen or air. It is also formed through the heating of fluorine, water, oxygen, and through the exposure of air to ultraviolet irradiation or X-rays. A light-blue gas with a distinctive odor, it is highly oxidative and is used for sterilization, bleaching, and oxidation purposes.
Since ozone is highly poisonous, large concentrations of it can affect the respiratory system. Even a small quantity of this gas can be toxic if inhaled for long periods.
Normal concentration of ozone in the atmosphere is between 0 and 0.03 ppm, but when ozone emissions from the "Ozone Emitting Equipment and Devices" table below are added to the normal atmospheric level, the concentration could reach up to 0.1 ppm.

• Ozone Exposure Concentration and Its Physical Effects

Ozone (ppm)	Effects
0.01 to 0.02	Odor is somewhat detectable by smell (but after a while, it becomes indistinguishable).
0.1	Odor is clearly detectable by smell. Nose and throat can feel an irritating sensation.
0.2 to 0.6	Impairs vision after 3 to 6 hours of exposure
0.5	Definite irritating sensation can be felt in upper respiratory passage.
1 to 2	Headache, chest pain, dryness in upper respiratory passage, and coughing after 2 hours of exposure. Repeated exposure can cause chronic poisoning.

Reference: Hidetoshi Sugimitsu, *Ozone no Kiso to Oyo ("Basis and Application of Ozone")* Korin Co., Inc., (1996)

• Standard Ozone Concentration in Working Environments in Various Countries

Country	Ozone concentration (ppm)
Australia	0.1
Belgium	0.1 *
Denmark	0.1
Finland	0.1
France	0.1
Germany	0.1

Country	Ozone concentration (ppm)
Japan	0.1
Sweden	0.1
Switzerland	0.1
Great Britain	0.1
United States	0.1 *
Russia	0.1

TWA — Time Weighted Average: Level of ozone that is considered non-hazardous to almost all workers if the time average of ozone exposure concentration is below the indicated value. This condition applies when workers are engaged in physically light labor for 8 hours a day, 40 hours a week.

*STEL — Short Time Exposure Limit: Applied to toxic substances that mainly affect living organisms after short time exposure. For our purposes, it refers to a level of ozone that is considered non-hazardous to almost all workers if the time average value for 15 minutes is below the indicated value.

Reference: ILO OCCUPATIONAL SAFETY AND HEALTH SERIES NO. 37 (THIRD EDITION 1991)

• Ozone Emitting Equipment and Devices

Because ozone is easily formed by electric discharges or light energy, many ozone emitting devices may be found in the workplace or in the home.

Devices	Ozone formation	Ozone concentration	Environment
Air purifier	Corona discharge	A few ppm	Office environment, Household environment
Sterilizer	Ultraviolet light	A few ppm	Office environment, Household environment
Ultraviolet curing device	Ultraviolet light	A few dozen ppm	Industrial environment
Copy machine, Printer	Corona discharge	Up to a few dozen ppm	Office environment, Household environment
Welding machine	Ultraviolet rays, Arc discharge	A few ppm	Industrial environment
Static removal equipment	Electrical discharge	A few dozen ppm	Industrial environment, Office environment
Surface finishing machine	Electrical discharge, Ozonizer	More than a hundred and less than 100,000 ppm	Industrial environment
Electron beam, X-ray irradiation machine	Electron beam, X-rays	More than a hundred and less than 10,000 ppm	Industrial environment
High voltage electric generating plant	Electrical discharge	Up to a few dozen ppm	Industrial environment
Semiconductor dry cleaner	Ultraviolet light, Electrical discharge	More than a hundred and less than 100,000 ppm	Industrial environment
Electric dust collector	Corona discharge	A few ppm	Industrial environment

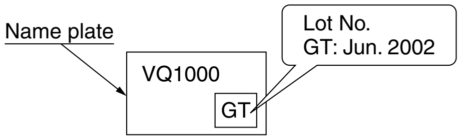
Reference: Shigeyuki Ota and Hironori Shimizu (Eds) *Ozone Riyo no Riron to Jissai ("Theory and Practice of Ozone Use")* Riaraizu Co., Inc., (1989)

List of Ozone Resistant Products

Ozone resistant products are categorized into the following three types.

1) Standard

These products standardly adopt HNBR. These products can be used in ozone environments with an ozone concentration of 0.03 ppm or less.
The following table shows the applicable products and start date (Lot no./Date of manufacture).
To confirm whether a product currently being used is an ozone resistant product, check the indication on the label of the product and package (bag).
Please check the lot no., and refer to the following table.



∗ The products indicated with [—] in the lot no./date of manufacture column are "ozone resistant products since their initial release," or "products which do not require measures (no parts included which may deteriorate by ozone)."

2) Series 80- (special product)

Products will be handled as ozone resistant products by adding "80-" to the beginning of the part no.
Example) 80-VK3140-5G-01

3) Special Order

Products will be handled as a special order after a specification meeting is held. Please contact SMC.

Products other than Ozone Resistant Products

Oil films including grease are effective at protecting NBR parts from ozone attack. Therefore, actuators and sealants with grease applied are not categorized as ozone resistant products.

Directional Control Valves

Standard

Description	Series	Lot No./Manufacture Date
4/5 port solenoid valve	SJ2000, 3000	—
	SY3000, 5000, 7000 (Plug-in)	—
	SY3000, 5000, 7000, 9000	FO/Mar. 2001
	SV1000, 2000, 3000, 4000	EY/Nov. 2000
	SYJ3000, 5000, 7000	FO/Jan. 2001
	SZ3000	DX/Oct. 1999
	SX3000, 5000, 7000	ER/Apr. 2000
	VF1000, 3000, 5000	MX/Oct. 2008
	VP4□50, 4□70	—
	S0700	—
	VQ0000, 1000, 2000	GO/Jan. 2002
	VQ4000	GO/Jan. 2002
	VQ5000	GO/Jan. 2002
	VQC1000, 2000, 4000	GO/Jan. 2002
	VQZ1000, 2000, 3000	GO/Jan. 2002
	SQ1000, 2000	ER/Apr. 2000
	VQD1000	EV/Aug. 2000
3 port solenoid valve	SYJ300, 500, 700	FO/Jan. 2001
	VQZ100, 200, 300	FX/Oct. 2001
	VP300, 500, 700	MU/Jul. 2008
	VP3145, 3165, 3185	—
	V100	FO/Jan. 2001
	SY100	GO/Jan. 2002
	SY300, 500	GO/Jan. 2002
	S070	—
	VQ100	EO/Jan. 2000
Air operated valve	SYA3000, 5000, 7000	FO/Jan. 2001
	SYJA3000, 5000, 7000	FO/Jan. 2001
	VPA4□50, 4□70	—
	SYJA300, 500, 700	FO/Jan. 2001
	VPA300, 500, 700	MU/Jul. 2008
	VPA3145, 3165, 3185	—
	VCC	—
Hand valve	VH	—
Residual pressure relief 3 port hand valve	VHS20 to 50	—

Series 80-

Description	Series
4/5 port solenoid valve	VZ1000, 3000, 5000
	VFS1000 to 6000
	VFR2000 to 6000
	VQ7-6, 7-8
	VK3000
	VP7-6, 7-8
	VPN-6, -8
3 port solenoid valve	VZ100, 300, 500
	VG342
	VKF300
	VK300
	VT317
	VT315, 325
	VS3115, 3110, 3135, 3145
Air operated valve	VFA3000, 4000, 5000
	VFRA3000, 5000
	VTA301, 315
Mechanical valve	VM, VZM, VFM
Transmitters	VR1210, 1220
	VR2110
	VR3200, 3201
Residual pressure relief 3 port hand valve	VHS40□
	VHS50□

Special Order

Description	Series
4/5 port solenoid valve	VZS2000, 3000
	VS4□10
3 port solenoid valve	VZ200, 400
	VGA342
	VT307 (Body ported only)
Air operated valve	VZA2000, 4000
	VSA4□20, 4□30, 4□40
	VZA200, 400
Finger valve	VHK
Power valve	VEX1
	VEX3

Vacuum Equipment

Standard

Description	Series	Lot No./Manufacture Date
Vacuum ejector	ZQ	GZ/Dec. 2002
	ZA	—
	ZX	DX/Oct. 1999
	ZH	YO/Jan. 1994
	ZU	ZO/Jan. 1995
	ZYY, ZYX	—
Multistage ejector	ZL	—
Compact vacuum unit	ZB	—
Vacuum unit	ZK2	—
Vacuum/Release unit	VQD1000-V	—
Air suction filter	ZFB	—
In-line air filter	ZFC	—
Drain separator for vacuum	AMJ	—

Series 80-

Description	Series
Vacuum ejector	ZR
	ZM

Special Order

Description	Series
∗ **Free mount cylinder for vacuum**	ZCUK
∗ **Vacuum pads**	ZP, ZPT, ZPTX
	ZP, ZP2, ZP3
Vacuum saving valve	ZP2V

∗ Please contact SMC as it changes with the pad material.

Air Preparation Equipment

Standard

Description	Series	Lot No./Manufacture Date
Aftercooler	HAA	—
	HAW	—
Air tank	AT	—
Dryer	IDU, IDF	—
Water separator	AMG	—
Filter	AFF	—
	AM	—
	AMD	—
	AMH	—
	AME	—
	AMF	—
Auto drain	AD402, 600	—
	ADM200	—
	ADH4000	—
Clean gas filter	SFA	—
	SFB	—
	SFC	—

Series 80-

Description	Series
—	—

Special Order

Description	Series
—	—

Air Preparation Equipment/Related Equipment

Standard

Description	Series	Lot No./Manufacture Date
Differential pressure gauge	GD40-2-01	—

Series 80-

Description	Series
—	—

Special Order

Description	Series
—	—

Modular F. R. L.

Standard

Description	Series	Lot No./Manufacture Date
F.R.L. unit	AC□□(A/B/C/D)-A	—
	AC□□(A/B/C/D)-B	—
	AC□□(A/B/C/D)-D	—
Filter	AF□□-A	—
	AFM□□-A	—
	AFD□□-A	—
	AF□□-D	—
	AFM□□-D	—
	AFD□□-D	—
Regulator	AR□□-A	—
	AR□□-B	—
	AR□□K	FY/Nov. 2001
	ARG□□	IQ/Mar. 2004
	ARG□□K	IQ/Mar. 2004
	AR□□(K)-D	—
	AR□□M(K)-D	—
	ARG□□(K)-B	—
Lubricator	AL□□-A	—
	AL□□-D	—
Filter regulator	AW□□-A	—
	AW□□-B	—
	AW□□K	FY/Nov. 2001
	AWM□□	FY/Nov. 2001
	AWD□□	FY/Nov. 2001
	AWG□□	IQ/Mar. 2004
	AWG□□K	IQ/Mar. 2004
	AW□□(K)-D	—
	AWG□□(K)-B	—
Filter	AF800, 900	—
Air combination	ACG□□	IQ/Mar. 2004
	ACG□□-B	—
Soft start-up valve	AV2000, 3000, 4000	OR/Apr. 2010
	AV5000	EU/Jul. 2000

Series 80-

Description	Series
—	—

Special Order

Description	Series
—	—

Pressure Control Equipment

Standard

Description	Series	Lot No./Manufacture Date
Regulator	ARJ	DW/Sep. 1999
	AR□25, □35	EU/Jul. 2000
Manifold regulator	ARM5	JV/Aug. 2005
	ARM10/11	GU/Jul. 2002
	ARM	EQ/Mar. 2000
Clean regulators	SRP1000	DR/Apr. 1999
Spacer type regulator	ARBQ4000, 5000	FR/Apr. 2001
	ARBYJ5000, 7000	DX/Oct. 1999
MR unit	AMR	ER/Apr. 2000
Vacuum regulator	IRV10, 20	—
Vacuum regulator	ITV0000	—
	ITV1000	MX/Oct. 2008
	ITV2000	MX/Oct. 2008
	ITV3000	MX/Oct. 2008
	ITV0090	—
	ITV2090	MX/Oct. 2008
Power amplifier for electro-pneumatic proportional valve	VEA	—
Controller for electro-pneumatic regulator	IC	—
Booster regulator	VBA□A	LX/Oct. 2007
Air tank	VBAT05A, 10A, 20A, 38A	JX/Oct. 2005
	VBAT05S, 10S, 20S, 38S	KW/Sep. 2006
	VBAT□A1, VBAT□S1	NW/Sep. 2009

Series 80-

Description	Series
Precision regulator	IR1000, 2000, 3000
Precision regulator	VEX1□30, 1□33

Special Order

Description	Series
Electro-pneumatic proportional valve	VEF, VEP
	VER2000, 4000
E-P HYREG®	VY1

Lubrication Equipment

Standard

Description	Series	Lot No./Manufacture Date
Lubricator	AL800, 900	—
Lubrication equipment	ALF	—
	ALT	—
	ALD	—
	ALB	—

Series 80-

Description	Series
—	—

Special Order

Description	Series
Lock-up valve	IL
Filter regulator	IW

Fittings and Tubing

Standard

Description	Series	Lot No./Manufacture Date
Fittings	KQ2, KQ2 Uni	—
	KS, KX	—
	KM	—
	KF	—
	M	—
	H, D, L, LL	—
	KC	—
	KJ	—
Fittings	DM	—
	KDM	—
	KB	—
	KR	—
	KRM	—
	KA	—
	KG	—
	MS	—
S couplers	KK	EO/Jan. 2000
	KKH	FW/Sep. 2001
	KKA	GX/Oct. 2002
Tubing	T□	—
	TM, TMA	—
Rotary joint	MQR	—

Series 80-

Description	Series
—	—

Special Order

Description	Series
—	—

Flow control equipment

Standard

Description	Series	Lot No./Manufacture Date
Speed controller	AS Elbow type (Metal body)	DZ/Dec. 1999
	AS□□□□F (One-touch)	EX/Oct. 2000
	AS Universal type	EX/Oct. 2000
	AS□□□1F-3	EX/Oct. 2000
	ASD	DZ/Dec. 1999
	AS□□□□FE	EX/Oct. 2000
	AS□□□□FG	EX/Oct. 2000
	AS□2□1FPQ	EX/Oct. 2000
	AS□2□1FPG	EX/Oct. 2000
	AS□□□□FM	EX/Oct. 2000
	AS□□□□M	EX/Dec. 1999
	AS□□□1F-D	EX/Oct. 2000
	ASD□□□-F-D	EX/Oct. 2000
	AS□2□0-D	DZ/Dec. 1999
	AS□□□1F-T	EX/Oct. 2000
	ASD□□□-F-T	EX/Oct. 2000
	AS□2□0-T	DZ/Dec. 1999
	AS-FS	—
Exhaust controller	ASV	FT/Jun. 2001
Metering valve	ASN2	—
Air saving valve	ASR, ASQ	—
Check valve	AKM	IO/Jan. 2004
Quick exhaust valve	AQ□□□F	FT/Jun. 2001

Series 80-

Description	Series
Quick exhaust valve	AQ
Check valve	AK
	AKA
	AKB
Speed controller	AS Large flow in-line type (Metal body)
	AS In-line type (Metal body)

Special Order

Description	Series
Extension prevention system	ASS (SSC)

Silencers/Exhaust Cleaners/Blow Guns/Pressure Gauges

Standard

Description	Series	Lot No./Manufacture Date
Silencer	AN	—
Exhaust cleaner	AMC	—
Blow gun	VMG	FY/Nov. 2001
Pressure gauge	G□	—
	G46E	—
	G49	—
	G46-□-□-SRA, B	—
	GP46	—
	GS40	—
	PPA	—

Series 80-

Description	Series
—	—

Special Order

Description	Series
—	—

Switches/Sensors

Standard

Description	Series	Lot No./Manufacture Date
Pressure switch	ZSE/ISE30A	—
	ZSE/ISE40A	—
	ZSE/ISE10 (M5/M5R type)	—
	ISE70, ISE75 (H)	—
	ZSE/ISE80	—
	ZSE3, ISE3	—
	ZSE1, ISE1	—
	ZSE2, ISE2	—
	ZSP1	—
	PS1000	—
	ISE35	—
	PSE530	—
	PSE540	—
	PSE550	—
	PSE560	—
	IS3000	GW/Sep. 2002
Air catch sensor	ISA2	—
Pressure switch	ISG	—
	IS2761	—
	ZSM1	—
Flow switch Flow sensor	PFMV5	—
	PF2A	—
	IF3	—
	PFM7	—
2-color display digital flow switch	PFM	—
	PFMB	—

Series 80-

Description	Series
—	—

Special Order

Description	Series
—	—

Noncompliant

Description	Series
Gap checker	ISA3
Pressure switch Note 1)	ZSE/ISE10 (01/N01 type)
Pressure switch	80-IS10

Note 1) Gasket of M5 fitting is used.
The rubber liner is made of NBR.

Process Valves

Standard

Description	Series	Lot No./Manufacture Date
2/3 port valve for fluid control	VQ20, 30	FD/Jan. 2001
	VND	—
	VCA	—

Options *

* Optional seal material: Select fluoropolymer

Description	Series
2/3 port valve for fluid control	VX2
	VXD2
	VXZ
	VXP2
	VXF
	VX3
	VXA
	VDW10, 20, 30
	VDW200, 300

Series 80-

Description	Series
—	—

Special Order

Description	Series
—	—

Chemical Liquid Valves/Fittings & Needle Valves/Tubing

Standard

Description	Series	Lot No./Manufacture Date
Fluoropolymer fitting	LQ	—
Chemical liquid valve	LVC	—
	LVA Note 1)	—
	LVD	—
	LVQ	—
High purity fluoropolymer needle valve	LVN	—
Tubing	TL, TIL	—

Note 1) The diaphragm material PTFE is ozone resistant as standard. The diaphragm materials NBR and EPDM are not ozone resistant.

Series 80-

Description	Series
—	—

Special Order

Description	Series
—	—

Process Pumps

Standard

Description	Series	Lot No./Manufacture Date
Process pump	PA(P)33□	FQ/Mar. 2001
	PB□A	NS/May 2009
	PAF	JY/Nov. 2005

Series 80-

Description	Series
—	—

Special Order

Description	Series
Process pump	PA

Temperature Control Equipment

Standard

Description	Series	Lot No./Manufacture Date
Air-thermo	HEA	—

Series 80-

Description	Series
—	—

Special Order

Description	Series
—	—

High Vacuum Equipment

Standard

Description	Series	Lot No./Manufacture Date
Angle valve	Series XL□	—
Angle valve	Series XM□	—
In-line valve	Series XY□	—
Straight solenoid valve	Series XSA	—
Smooth vent valve	Series XVD	—

Series 80-

Description	Series
—	—

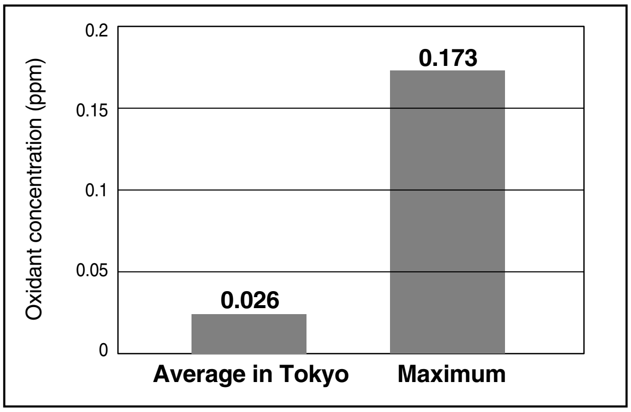
Special Order

Description	Series
—	—

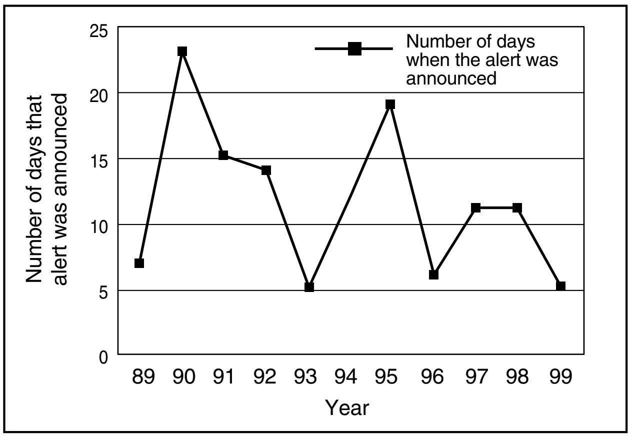
Photochemical Oxidants

"Photochemical oxidants" is a general term used to refer to a type of secondary pollutants that in their original (primary state) are mainly composed of industrial and automobile emissions of nitrogen oxide (NO_X) and hydrocarbons (HC). When these contaminants are exposed to sunlight irradiation, they experience a photochemical reaction that changes their composition into photochemical oxidants. The adverse environmental effects of their altered secondary nature are equivalent to a 60 to 90% concentration of ozone.
According to a Tokyo Environmental White Paper, although the maximum concentration of photochemical oxidants recorded during daytime hours (5 a.m to 8 p.m.) in 1999 was 0.173ppm, the average concentration recorded for that years was 0.026ppm. Therefore, it seems unlikely that there would be enough concentration of photochemical oxidants to cause adverse effects on pneumatic equipment.

Oxidant concentration in Tokyo, 1999



Photochemical smog emergency alert (Tokyo)



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