

Long-Lifetime FEPM TOUGHUORO™

1. Introduction

Tetrafluoroethylene propylene rubber (FEPM) is a type of fluororubber (FKM). It is a copolymer of tetrafluoroethylene (TFE) and propylene (P) and has a different molecular structure compared to ordinary fluororubber (FKM; copolymer of vinylidene fluoride (VDF) and hexafluoropropene (HFP)).

Table1 shows the molecular structure of FEPM and FKM.

Table1 Molecular structure of FEPM and FKM

Type	Molecular structure
FEPM	$-(CF_2-CF_2)_p-(\overset{\text{CH}_3}{\text{CH}}-CH_2)_q-$ <p style="text-align: center;">TFE P</p>
FKM (Copolymer)	$-(CF_2-CH_2)_p-(\overset{\text{CF}_3}{\text{CF}}-CF_2)_q-$ <p style="text-align: center;">VDF HFP</p>

With this molecular structure, FEPM has characteristics such as superior steam resistance and chemical resistance which were weak points for FKM. FEPM is used as sealing for food and beverages facilities and sealing for tire vulcanizing devices.

However, with advancements in functionality of facilities and downsizing, the chemicals used for cleaning the facilities have become higher in temperature and concentration, and facilities are used in tougher environments, leading to more demanding properties for sealing material.

In this article, we will introduce the steam-resistant SS series and low compression set ZS series of TOUGHUORO™ that we have developed as a long-

lifetime FEPM with improved heat resistance and steam resistance by utilizing our proprietary mixing design technology.

2. Characteristics of TOUGHUORO™

Compared to our existing FEPM, D0970 and D0890, TOUGHUORO™ is a material with significantly improved heat resistance and steam resistance. Below are the various characteristics of TOUGHUORO™.

2- 1) Compression set characteristics properties

Compression set is used as an indicator for heat resistance in sealing material.

Under the same environment, a smaller compression set means the sealing material can be used favorably for a longer period of time.

Figure1 shows the measurement and calculation methods for compression set.

In general, compression set of 80% is considered as sufficient for life expectancy of material used for sealing¹⁾, but the compression set of TOUGHUORO™ showed better results than our existing FEPM and it is anticipated to have a 4-fold longer in air at 200°C.

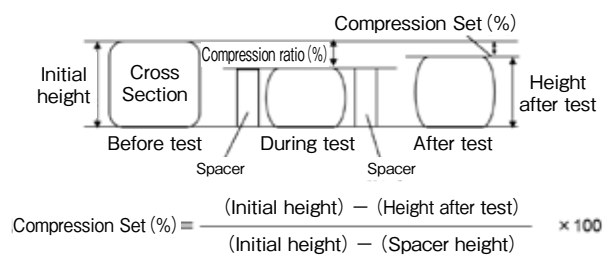


Figure1 Measurement and calculation methods for Compression Set

Figure2 shows the results for compression set in air at 200°C.

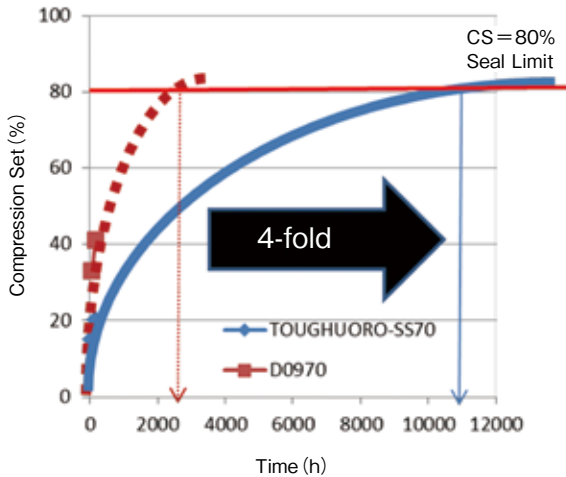


Figure2 Compression Set in air at 200°C

2-2) Steam resistance properties

Under steam conditions, HNBR and EPDM have been used conventionally to suppress foaming phenomenon called blister²⁾, but in conditions over 150°C, it was difficult to use these materials due to their characteristics. Our newly developed TOUGHUORO™ has improved mechanical strength as well and even under 230°C steam conditions, no signs of blisters were confirmed, making it possible to use as a good sealing material. Figure3 shows the application area in steam of TOUGHUORO™ and various materials.

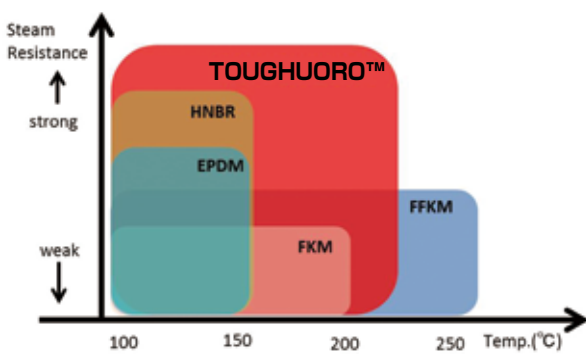


Figure3 Applicable area in steam of TOUGHUORO™ and various materials

Figure4 shows a cross-section of the sample after compression set test in steam at 230°C.



No blister
TOUGHUORO™-SS70
blister
D0970

Figure4 Cross section of specimen after Compression Set test in steam at 230°C

2-3) Acid resistance and alkali resistance properties

Regarding acid resistance and alkali resistance of TOUGHUORO™-SS70, it is equivalent or higher than that of D0970. Since heat resistance of TOUGHUORO™ has improved, it can be used under higher thermal conditions.

Figure5 shows the results for change in volume after the acid and alkali immersion test.

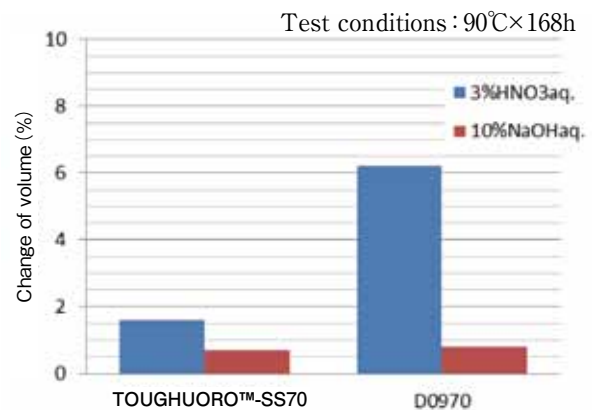


Figure5 Change in volume of TOUGHUORO™ after acid and alkaline immersion test

2-4) Water-glycol based flame-retardant hydraulic oil resistance properties

Resistance of TOUGHUORO™-SS90 to water-glycol flame-retardant hydraulic oil (HYDOL HAW, manufactured by MORESCO) is equivalent or higher than D0890.

The pass or fail judgment was made by stretch change ratio and volume change ratio (judgment criteria: within ±50% change in elongation, within +10% change in volume were judged as ○, those that

slightly exceeded the criteria were judged as △, those that clearly exceeded the criteria were judged as ×³⁾. Table2 shows the resistance of TOUGHUORO™ to water-glycol based flame-retardant hydraulic oil.

Table2 Resistance of TOUGHUORO™ to water-glycol based flame-retardant hydraulic oil

	TOUGHUORO™-SS90	D0890
Change in Elongation	○	○
Change in Volume	○	○

Test conditions : 120°C×1000h

It was confirmed that TOUGHUORO™-SS90 is superior in regards to compression set and it is anticipated to enable use for a longer period. Figure6 shows the compression set after the water-glycol based flame-retardant hydraulic oil test.

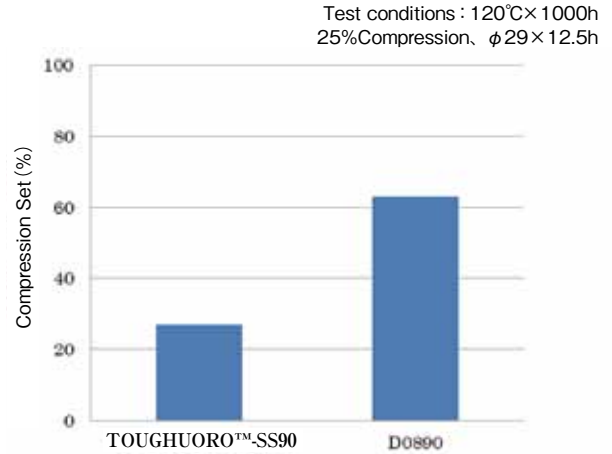


Figure6 Compression Set of TOUGHUORO™ to water-glycol based fire-retardant hydraulic oil

Table3 Material characteristics of TOUGHUORO™

Material name	Developmental products			
	Steam-resistant SS series			Low compression set ZS series
	TOUGHUORO™-SS70	TOUGHUORO™-SS80	TOUGHUORO™-SS90	TOUGHUORO™-ZS80
physical properties				
Hardness (ShoreA)	74	84	90	85
Tensile strength (MPa)	23.1	24.6	22.8	24.3
Elongation (%)	190	150	110	120
100% Modulus (MPa)	8.3	15.2	20.9	19.9
Compression set test_200°C×70h				
Compression set (%) in air	16	19	18	14
Compression set (%) in steam	14	20	18	11
Compression set test_230°C×70h				
Compression set (%) in air	22	26	27	21
Compression set (%) in steam	20	26	27	19

The values are measured values, not standard values.

2-5) Food Sanitation Act

TOUGHUORO™ is a material conforming to the criteria designated in the Ministry of Health, Labour and Welfare Notification No. 595 (Dissolution conditions: Used at temperatures over 100°C).

2-6) Product shape

TOUGHUORO™ can be manufactured into products with various cross-section shapes and large-diameters such as O-rings (No.4640), V packing (No.4631) and X-rings (No.4641).

2-7) Mechanical properties

There are two grades of TOUGHUORO™, the steam resistant SS series and the low compression set ZS series.

Table3 shows the physical characteristics and compression set in 200°C air/steam for each grade.

3. TOUGHUORO™ applications

TOUGHUORO™ has superior heat resistance and steam resistance and the following uses are considered:

1. Mining market
Bit seals
2. Steel market

Rotary joint seals

3. Tire manufacturing market
Sealing for curing press to car tire
4. Food and beverages market
Sealing for food and beverages facilities
5. Nuclear power market
High-temperature, dynamic seals

4. Conclusions

TOUGHUORO™ introduced in this article is a material that shows its best characteristics in high temperature steam conditions. In the future, higher demands may be placed on sealing material, but it is considered that this would be able to sufficiently answer those demands.

We would like to continue developing new materials and improving existing materials to correspond to the requests of our users.

5. References

- 1) Toshio Kawamura: Valqua Review, Vol26, No.6 (1982)
- 2) Hirofumi Zushi: Valqua Technology News, No.31 (2016)
- 3) Ken Suzuki: Valqua Technology News, No.24 (2013)

*"TOUGHUORO" is a trademark of VALQUA, LTD.



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