The expired period of Liquefied Petroleum Gas (LPG) rubber hose supports consumer safety aspects

A B Mulyono1,2 and E H Purwanto1,3

1 Center for Research and Human Resource Development, National Standardization Agency, South Tangerang, Banten, Indonesia

Email: 2 arybudimulyono1988@gmail.com, 3 endi@bsn.go.id

Abstract. Liquefied Petroleum Gas (LPG) rubber hose has the corrosive characteristic with hydrocarbon compounds (butane and propane). This makes LPG rubber hose has an expired period. Standards or technical specifications are needed to guarantee the quality of the product and increasing product safety. Until now, the expired period of LPG hose has not been regulated in the Indonesian National Standard (SNI). This study aims to analyse expired period of LPG rubber hose for gas stoves. In this study, the descriptive qualitative method is used based on primary data (questionnaire and interview) and secondary data (literature study). The result of this study concluded that the determination of LPG rubber hose expired period based on shelf life and service life. The service life of rubber hose will vary due to different raw materials, additives, and usage conditions (time, temperature, pressure, and environment). Seventy-five percent (75%) of LPG rubber hose industry respondents conducted research on LPG rubber hoses service life and recommended service life period is one year.

1. Introduction

The government has launched Kerosene to Liquefied Petroleum Gas (LPG) conversion program that aims to diversify energy supplies in order to reduce dependence on fuel oil and efficiency of the government budget. Before the conversion program began, the government budgeted a trillion rupiah to subsidize kerosene [1]. The kerosene to LPG conversion program is based on Law No.22/2001 concerning Oil and Gas, Presidential Regulation No.5/2006 concerning the National Energy Policy, and Presidential Regulation No.104/2007 concerning the Supply, Distribution, and Determination of Liquefied Petroleum Gas (LPG) 3 kg cylinders. Until 2017, Bank of Indonesia (BI) stated that kerosene to LPG conversion program carried out by the government since 2007 has provided savings of 197 trillion rupiah [2].

Until now, the government continues Kerosene to Liquefied Petroleum Gas (LPG) conversion program. Based on the Minister of Energy and Mineral Resources Regulation, Pertamina has a mandate to carry out the supply and distribution of 531,131 three kilo LPG in 2018. The kerosene to Liquefied Petroleum Gas (LPG) conversion program has successfully increased percentage of households using LPG from 6.4% to 91.1% (2007-2013) [3].

This program has several problems in its implementation. Problems that arise include leakage and explosion of LPG cylinders [4]. Most of the fires caused by LPG gas cylinders explode are due to leaks in gas distribution channels (including valves, hoses, regulators, and clamps) [5] [6]. The leakage of LPG rubber hoses influenced by several factors including rat bites, sharp object incisions, flames exposure, and direct contact with the environment that causes physical properties changes of LPG rubber hoses.

Rubber hose serves to deliver LPG with a certain pressure from the gas cylinder to gas stove. A good quality rubber hose must have good resistance to LPG [7]. Rubber hose has three main parts, there are rubber hose tube, reinforcement layer, and cover layer. Rubber hose tubes are used to withstand the pressure caused by gas. Reinforcement layers are used to resist mechanical stresses received by the hose,
such as internal pressure, vacuum, or tensile pressure. The cover layer is used to protect the amplifier from external pressure, weather and ozone, chemical pressure, and thermal stress.

Standards are technical requirement, including procedures and methods that are prepared based on consensus in accordance with requirements of safety, security, health, environment, science and technology development, experience, as well as current and future developments [8]. Standards are based on the needs and results of the consensus of stakeholders to achieve various economic, social, and environmental aspects supporting sustainable development [9]. Indonesia National Standard (SNI) is standard established by National Standardization Agency of Indonesia (BSN) and applies in Indonesia [9]. National Standardization Agency of Indonesia BSN has established 2 (two) SNI for LPG hoses, SNI 7213: 2014 Rubber Hoses for LPG Gas Stoves, and SNI 8022: 2014 Elastomer thermoplastic hoses for LPG gas stoves. Both SNIs are mandatory regulated by the Ministry of Industry to protect consumers.

Technical standards or specifications are needed to guarantee product quality and improve LPG hose product safety. In 2009, research conducted by The Centre of Research and Development – National Standardization Agency of Indonesia showed the level of conformity of LPG gas stove rubber hose products to Indonesian National Standard (SNI) requirements is still low. There are indications that the age factor also affects the quality of rubber hose characteristics. It is known that rubber has corrosive susceptibility to hydrocarbon compounds including butane and propane, so that each component such as rubber hose, regulator, and rubber seal have a service life (expired period). As the warranty period expires, the component quality will automatically continue to decline.

Until now, only LPG gas cylinders have a procedure to determine the expired period by retesting LPG gas cylinders every five years after manufactured, while the determination of the expired period of the LPG hose has not been regulated. The purpose of this study was to analyse the expired period for LPG rubber hoses.

2. Method
This study uses qualitative descriptive method. Descriptive analysis is used to collect information by giving attention as much as possible aspects to obtain the overall actual situation. The qualitative method addresses the social aspect of research. The researcher uses open-ended questions and interviews subjects in a semi-structured fashion [10]. The qualitative method also emphasizes data sampling conducted purposively and the research results emphasize in meaning than generalization [11]. Primary data collection is done by interview using a questionnaire, while secondary data obtained through a literature study. Primary data collected are from LPG rubber hose manufacturers and LPG rubber hose consumers. The survey respondents were carried out by purposive sampling (nonprobability sampling) in Medan, Bogor, Depok, Bekasi, Tangerang, and Surabaya.

3. Result and Discussion
3.1. Standardization of LPG Rubber Hose Expired Period
Liquefied Petroleum Gas (LPG) rubber hose is one of the products used to complement the LPG gas stoves. This product must meet not only quality requirements but also technical age. If the product has exceeded its technical age (expired period) but is still being used, then it could cause a fire hazard. The expired period can be divided into [12] [13]:

- Shelf life: the period from receipt or delivery by distributor until the product begins to be used.
- Service life: the period from installation to product replacement.

In this study, identification of standards related to the procedure for rubber and elastomeric products storage can be seen in Table 1.

In these four standards, there are correct procedure recommendations for rubber and elastomeric products storage, so that shelf life of rubber and elastomeric products can be optimized. Recommended procedures for rubber products and elastomers storage can be summarized and seen in Table 2.
Table 1. Standards relating to procedures for rubber and elastomeric products storage.

| No | Standard Number | Standard Title |
|----|-----------------|----------------|
| 1  | DIN 7716: 1982  | Rubber products; requirements for storage, cleaning and maintenance |
| 2  | BS 4F 68: 2002  | Controlled storage of vulcanized rubbers for use in aerospace applications |
| 3  | ISO 2230: 2002  | Rubber products - Guidelines for storage |
| 4  | DIN 9088: 2002  | Aerospace Series - Storage life of rubber products |

Table 2. Recommended procedures for rubber products and elastomers storage (based on Standards).

| Storage Parameters       | Storage recommendation                                                                 |
|--------------------------|----------------------------------------------------------------------------------------|
| Temperature              | Storage temperature between 5 °C to 25 °C. Avoid contact with heat sources such as boilers, radiators, and direct sunlight |
| Humidity                 | Storage humidity must below 70%. Avoid conditions too humid or too dry. Condensation should not occur. |
| Light exposure           | Must be protected from light sources, especially direct sunlight or artificial light that contains ultraviolet. Storage containers offer the best protection as long as their packaging is ultraviolet resistant. It is recommended to close all windows in the storage room with red/orange coating screen. |
| Radiation                | Must be protected from all types of ionizing radiation sources which can cause damage to the product. |
| Oxygen Dan Ozone         | Elastomeric material must be protected from air circulation by wrapping packages or airtight packages. Because Ozone is destructive to elastomers, storage space must not contain equipment that produces ozone. |
| Deformation              | Elastomeric material should be stored as far as possible under conditions of tension, compression or other deformation. |
| Liquid or semi-solid contact | Avoid contact with solvents, oils, greases, or other semi-solid materials during storage |
| Contact with metals and non-metals | Avoid direct contact with certain metals, such as manganese, iron, brass, copper, and its alloys. These material components are known to have adverse effects on some rubber and elastomeric products. |

The shelf life of rubber products varies depending on the type of rubber used as raw material. International standards have been identified and reviewed related to the shelf life of LPG hoses. These standards can be seen in Table 3.

The shelf life of rubber hoses is influenced by many factors. The recommended shelf life of rubber and elastomers products can be seen in Table 4.

Table 3. International standard for rubber hose shelf life.

| No | Standard Number | Standard Title                                                                 |
|----|-----------------|------------------------------------------------------------------------------|
| 1  | ISO 2230 : 2002 | Rubber products — Guidelines for storage                                       |
| 2  | MIL-HDBK-695 (2017) | Rubber Products: Recommended Shelf Life                                       |
| 3  | SAE ARP 5316 (2014) | Storage of Elastomer Seals and Seal Assemblies Which Include An Elastomer Element Prior To Hardware Assembly |
Table 4. The recommended shelf life of elastomeric rubber hose products.

| Chemical Names                        | Chemical Abbreviation | ISO 2230: 2002 | MIL-HDBK-695 (2005) | SAE ARP 5316 (2002) |
|---------------------------------------|-----------------------|----------------|---------------------|---------------------|
| Polyacrylate                          | ACM, ANM              | --             | 20                  | --                  |
| Polyester Urethane                    | AU                    | --             | 3-5                 | 5                   |
| Chlorobutyl                           | CIR                   | --             | 10                  | --                  |
| Chlorinated Polyethylene              | CM                    | --             | 10                  | --                  |
| Polychloroprene                       | CR                    | 7-10           | 5-10                | 15                  |
| Chlorosulfonated Polyethylene         | CSM                   | --             | 5-10                | --                  |
| Epichlorohydrin H, EO                 | CO, ECO               | 7-10           | 5-10                | --                  |
| Polysulfide                           | EOT, T                | --             | 20                  | 20                  |
| Ethylene/Propylene/Diene              | EPDM                  | 10-15          | 5-10                | unlimited           |
| Polyether Urethane                    | EU                    | --             | 5-10                | 5                   |
| Tetrafluoroethylene/Propylene         | FEPM                  | --             | --                  | unlimited           |
| Perfluorocarbon                       | FFKM                  | --             | 20                  | unlimited           |
| Fluorocarbons                         | FKM                   | --             | 20                  | unlimited           |
| Fluoro Methyl Vinyl Silicone          | FVMQ                  | --             | 20                  | unlimited           |
| Polypropylene oxide                   | GPO                   | --             | 5-10                | --                  |
| Hydrogenated Nitrile                  | HNBR                  | 7-10           | 15                  | --                  |
| Isobutylene Isoprene                  | IIR                   | 7-10           | 5-10                | 15                  |
| Isoprene                              | IR                    | --             | 3-5                 | --                  |
| Butadiene Acrylonitrile               | NBR                   | 7-10           | 3-5                 | 15                  |
| Natural Rubber                        | NR                    | --             | 3-5                 | --                  |
| Butadiene Styrene                     | SBR                   | --             | 3-5                 | --                  |
| Methyl Vinyl Silicone                  | VMQ, Q                | 10-15          | 20                  | --                  |

Based on the literature study, some experts in Australia (ELGAS Australia) and United Kingdom (UK LPGenius) recommend LPG rubber hose to be replaced every five years. The service life of a polymer is difficult to predict because [14][15]:

- The characteristics of polymers depend on time, temperature, environment, and pressure.
- The property value at which the polymer fails is often unknown.
- The usage conditions of polymers may vary, and usage errors also occur frequently.
- For complex uses, it is not possible to be the same as the accelerated usage conditions test.
- The failure mechanism is not always sustainable - gradual changes in characteristic can occur.
- Polymers are inherent variables.
- Difficulties in conducting long-term testing.

The service life of rubber hose will vary due to different raw materials, additives, and usage conditions (time, temperature, pressure, and environment) [13][15][16]. While SNI does not state the raw materials used in the manufacture of LPG rubber hoses. Some additives which are added include heat stabilizer, ultraviolet stabilizer, antioxidant, and colorant.

3.2. Survey Results Supports Determination of LPG Rubber Hose Expired Period

To find out data/information needed to develop expired period of LPG rubber hoses, a survey was conducted using interviews with LPG rubber hoses manufacturer (4 manufacturers). The results are:

- All survey respondents (100%) stated that LPG rubber hose complies with SNI 7213: 2014 (Mandatory SNI). respondents stated that they did not experience any obstacles in fulfilling SNI
specifications. Respondents also stated that they did not use other standards as a reference in LPG rubber hoses production.

- 50% of respondents stated that fulfillment testing of SNI requirements on internal companies.

- 75% of respondents stated that they had LPG rubber hose expired period for 1 year as a safe limit approach. Determination of service life is based on results of internal research using the aging test method. However, manufacturers stated the service life was very dependent on storage and usage.

- 25% of respondents stated that they monitored products that were still circulating in the market related to the expired period (shelf life). While 75% of respondents said they did not monitor the products circulating in the market. This shows that the level of supervision of the company's products is still low. It is necessary to increase supervision so that the quality of products received by the public can be further improved.

- All survey respondents (100%) stated that the determination of the LPG rubber hoses expired period needs to be included in SNI 7213: 2014. Respondents stated that the expired period is very important so that the quality of LPG rubber hose produced remains guaranteed when the product is used by consumers. However, respondents stated that the determination of the LPG rubber hose expired period must also consider the economic calculation of the company's production.

In addition to the primary data collection in LPG rubber hose manufacturer, the survey was also conducted on LPG gas stoves consumers (22 respondents). This survey was conducted to determine problems encountered in rubber hoses usage. The results show frequent damages are bloated hose, melted hose, cracks, stretchy hose, blocked regulator, and leakage (rat).

4. Conclusion
Based on the results, it can be concluded that the determination of the LPG hose expired period includes shelf life (storage life) (see Table 4) and service life. Rubber hose storage conditions are the most important factor in determining the shelf life. The service life of rubber hose will vary due to different raw materials, additives, and usage conditions (time, temperature, pressure, and environment). The results show 75% LPG rubber hose manufacturer conducted research on LPG rubber hoses service life and obtained recommended service life period is 1 year. The shelf life of rubber hose needs to be stated in SNI 7213:2014 based on raw material specifications to ensure the product quality and increasing product safety.

Acknowledgment
This research was supported by National Standardization Agency of Indonesia. We would like to thank Mr. Mangasa Ritonga for his guidance in this research.

References
[1] Mentang SX. PERSEPSI, SIKAP DAN PARTISIPASI MASYARAKAT TERHADAP KONVERSI MINYAK TANAH KE GAS LPG (Studi di Kelurahan Taratara, Kecamatan Tomohon Barat, Tomohon). Center for Open Science; 2019 Apr 1. doi.org/10.31227/osf.io/4vnfs.

[2] Asyari H, Umar U. Desain Prototipe Kompor Listrik Tenaga Surya. Emitor. Universitas Muhammadiyah Surakarta; 2019 Mar 31;19(1):6–9. doi.org/10.23917/emitor.v19i1.6997.

[3] Andadari RK, Mulder P, Rietveld P. Energy poverty reduction by fuel switching. Impact evaluation of the LPG conversion program in Indonesia. Energy Policy. Elsevier BV; 2014 Mar;66:436–49. doi.org/10.1016/j.enpol.2013.11.021.

[4] Kusriyanto M, Firdaus, Yulianto A, Kurniawan S. Early detection of LPG gas leakage based Wireless Sensor Networking. Ma'mun S, Tamura H, Purnomo MRA, editors. MATEC Web of Conferences. EDP Sciences; 2018;154:01045. doi.org/10.1051/matecconf/201815401045.

[5] Dewi L, Somantri Y. Wireless Sensor Network on LPG Gas Leak Detection and Automatic Gas Regulator System Using Arduino. Mater. Sci. Eng. C. IOP Publishing; 2018 Jul;384:012064. doi.org/10.1088/1757-899X/384/1/012064.
[6] Rahman A, Istighfarin R. Augmented reality based learning media for virtual instruction of LPG cylinder assembly. EXPLORING RESOURCES, PROCESS AND DESIGN FOR SUSTAINABLE URBAN DEVELOPMENT. ICETIA. AIP Publishing; 2019. doi.org/10.1063/1.5112480.

[7] Handayani H, Faturrohman MI, Kinasih NA, Falaah AF. KARET ALAM EPOKSI SEBAGAI BAHAN BAKU PEMBUATAN KOMPONEN KARET PADA KATUP TABUNG DAN REGULATOR LPG. JPK. Riset Perkebunan Nusantara; 2018 Jan 11;35(2):199. doi.org/10.22302/ppk.jsp.v35i2.416.

[8] Sutanto J, Sulisworo P. Improvement of Nuclear Science Standards (SNI) to Meet Market Needs and Harmonization. J. Phys. IOP Publishing; 2019 Apr;1198(2):022010. doi.org/10.1088/1742-6596/1198/2/022010.

[9] Saleh AR, Sumarni E, Nihayati N, Bahrudin M. DISTRIBUSI STANDAR NASIONAL INDONESIA KEPADA MASYARAKAT MELALUI LAYANAN PERPUSTAKAAN. Jurnal Standardisasi. Center for Research and Development of Standardization; 2018 May 11;18(2):139. doi.org/10.31153/js.v18i2.706.

[10] MOHAJAN HK. QUALITATIVE RESEARCH METHODOLOGY IN SOCIAL SCIENCES AND RELATED SUBJECTS. JEDEP. Fundatia Romania de Maine; 2018 Mar 30;7(1):23. doi.org/10.26458/jedep.v7i1.571.

[11] Etikan I. Comparison of Convenience Sampling and Purposive Sampling. AJTAS. Science Publishing Group; 2016;5(1):1. doi.org/10.11648/j.ajtas.20160501.11.

[12] Das SS, Schroeder LW. Estimation of shelf life of natural rubber latex exam-gloves based on creep behavior. J Biomed Mater Res B. Wiley; 2008;85B(2):398–408. doi.org/10.1002/jbm.b.30958.

[13] Boyun BM, Rhoads JE. Elastomer Shelf Life: Aged Junk or Jewels? IEEE. Institute of Electrical and Electronics Engineers (IEEE); 1989 Jun;9(6):45–45. doi.org/10.1109/mper.1989.4310754.

[14] Hulme A, Cooper J. Life prediction of polymers for industry. Seal Tech. Elsevier BV; 2012 Sep;2012(9):8–12. doi.org/10.1016/s1350-4789(12)70398-7.

[15] Woo CS, Choi SS, Lee SB, Kim HS. Useful Lifetime Prediction of Rubber Components Using Accelerated Testing. IEEE. Institute of Electrical and Electronics Engineers (IEEE); 2010 Mar;59(1):11–7. doi.org/10.1109/tr.2010.2042103.

[16] Woo CS, Park HS. Useful lifetime prediction of rubber component. ENG FAIL ANAL. Elsevier BV; 2011 Oct;18(7):1645–51. doi.org/10.1016/j.engfailanal.2011.01.003