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Characterization of LPG Hose Quality to Improve Consumer Safety Protection

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Abstract: Standards or technical specifications of a product can guarantee product quality and improve product safety. To guarantee the quality of rubber and thermoplastic hose for LPG stoves circulating in the community, the government has established SNI 7213:2014 Rubber Hoses for LPG Gas Stoves and SNI 8022:2014 Thermoplastic Elastomer Hoses for LPG Gas Stoves. This study aims to identify the characteristics of the LPG hose test results based on SNI 7213:2014 and SNI 8022:2014. The test parameters tested were tensile strength, elongation at break, and aging at 100°C for 72 hours. This study used a quantitative descriptive method and the hose sample was taken using purposive sampling. The results showed that there were still samples of LPG hoses whose test results were close to the maximum/minimum limits of the established SNI quality requirements. This indicates the need for corrective steps to be taken by LPG hose manufacturers so that the LPG hose quality can reach optimal value.

Keywords: Indonesia National Standard (SNI), Liquefied petroleum gas (LPG) hose, quality, safety protection.

Abbreviations: Indonesia National Standard (SNI), Liquefied petroleum gas (LPG), National Standardization Agency (BSN)

Introduction

The Liquefied Petroleum Gas (LPG) hose is one of the main equipment for LPG gas stove. The raw material for LPG hoses can be made from rubber or thermoplastic materials. LPG thermoplastic elastomer hose are made by curing, reinforcing from thread or metal wire and given a covering layer. Meanwhile, LPG rubber hoses are made using a vulcanization process, reinforced with thread or metal wire and given a covering layer. The quality of the LPG hose is very important to ensure user safety. A good quality of LPG hose can prevent gas leaks which can cause fires (Leavline et al., 2017; Soundarya & Anchitaalagammai, 2014). Currently, the use of LPG hoses still encounters several problems. One of the problems that arises is the case of gas cylinder explosions which are caused by several causes, including LPG hose leaks (Dewi & Somantri, 2018; Kusriyanto et al., 2018; Saefullah et al., 2012). LPG hose leaks can occur due to several causes including exposure to fire/heat, environmental conditions, cuts from sharp objects, rat bites, and other causal factors (Mulyono & Purwanto, 2022). Standards can guarantee product quality and increase product safety when the product is used by consumers (Aswal, 2020; BSN, 2009; Jannah et al., 2020; Sialagan, 2013; Ulfiati, 2018). So it is necessary to implement standard requirements for LPG hose which can guarantee the quality of LPG hose produced by manufacturers and can provide consumer protection against potential dangers.

Standards are technical requirements that are prepared based on the consensus of all relevant parties (government, producers, consumers, experts) which consider safety, security, health, environmental requirements, developments in science and technology, experience and current developments. and the future to obtain maximum benefits (Pemerintah, 2014). The National Standardization Body (BSN) as the institution

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responsible for carrying out government duties in the field of Standardization and Conformity Assessment has established 2 (two) mandatory Indonesian National Standards (SNI) regarding LPG hose specifications. The Indonesian National Standards (SNI) are SNI 7213:2014 Rubber hose for LPG gas stoves and SNI 8022:2014 Thermoplastic elastomer hose for LPG gas stoves. SNI 7213:2014 is a revision of SNI 06-7213-2006 Rubber hose for LPG gas stoves. Revisions were made by adding articles on quality requirements for rubber hose compounds for gas stoves as well as changes to product quality requirements. Meanwhile, SNI 8022:2014 is the development of a new standard for quality requirements for LPG thermoplastic elastomer hoses.

The National Standardization Agency (BSN) conducted research on the level of conformity of LPG rubber hose to SNI quality requirements in 2009 (three years after the implementation of the kerosene-to-gas conversion policy). The research results show that there is still a need to improve the quality of LPG hose products in order to fulfill the quality requirements of the Indonesian National Standard (SNI). The results of other research concluded that a number of four LPG rubber hose manufacturers who were used as research respondents stated that they had implemented SNI 7213: 2014 and had not experienced problems in fulfilling the specified SNI specifications (Mulyono & Purwanto, 2021). In order to support sustainable evaluation of LPG hoses to SNI quality requirements, research is needed that identifies the fulfillment of LPG hoses quality requirements. This study aims to identify the characteristics of the LPG hose test results based on SNI 7213:2014 and SNI 8022:2014 for the quality requirements of tensile strength, elongation at break, and aging at 100^{o}C for 72 hours. By identifying the characteristics of LPG hose specification compliance with the parameters of tensile strength, elongation at break, and aging in SNI, it is hoped that producers/manufacturers can improve the quality of LPG hose products. So that the LPG hose circulating to consumers is an LPG hose that has good quality and can guarantee consumer safety protection.

Materials and Methods

The method used in this research is a quantitative descriptive method. Descriptive research is carried out by looking for information related to existing symptoms, clearly explaining the goals to be achieved, planning how to approach it, and collecting various kinds of data as material for making reports (Jayusman & Shavab, 2020). Kunto (2006) explains that the approach uses quantitative because it uses numbers, starting from data collection, interpretation of the data, and the appearance of the results. The materials used in this research are LPG rubber hose and LPG thermoplastic elastomer hose obtained by the manufacturer. The sample in the research was determined using purposive sampling. Purposive sampling is a form of sampling by researchers based on various criteria that may include specific knowledge of the research problem, and capacity or willingness to participate in research (Rai & Thapa, 2019). This study used three samples of LPG rubber hose and two samples of LPG thermoplastic elastomer hose.

In this research, LPG hose quality to improve consumer safety is based on the quality requirements in the Indonesian National Standard (SNI). This is because the application of SNI can support the realization of quality assurance for goods, services, processes, systems, or personnel so that it can provide confidence to customers and related parties that an organization, individual, goods, and/or services provided have met the specified requirements (Mulyono & Pudjiastuti, 2013). The SNI used as a reference for LPG hose quality requirements for tensile strength, elongation at break, and aging at 100^{o}C for 72 hours are SNI 7213:2014 Rubber hose for LPG gas stove and SNI 8022:2014 Thermoplastic elastomer hose for LPG gas stove. Testing is carried out in a testing laboratory that has been accredited by the National Accreditation Committee (KAN) for the scope of testing LPG rubber hose and LPG thermoplastic elastomer hose.

Results and Discussion

Test results for LPG rubber hose and LPG thermoplastic elastomer for tensile strength, elongation at break, and aging parameters

In this research, test results were obtained for LPG rubber hoses for the parameters tensile strength, elongation at break, and aging at 100°C for 72 hours using the SNI 7213:2014 which can be seen in Table 1. Test results for LPG elastomeric thermoplastic hoses were also obtained for the parameters tensile strength, elongation at break, and aging at 100°C for 72 hours using the SNI 8022:2014 which can be seen in Table 2

Table 1. Test results for LPG rubber hose (tensile strength, elongation at break, and aging parameters)

No.	Test	Test result for Rubber Hose A		Test result for Rubber Hose B		Test result for Rubber Hose C		Quality Requirement in SNI 7213:2014	
		Inner	Outer	Inner	Outer	Inner	Outer	Inner	Outer
1.	Tensile strength, MPa	13.6	8.8	17.4	14.5	8.4	7.6	Min 7 MPa	Min 7 Mpa
2.	Elongation at break, %	210	260	210	260	200	270	Min. 200%	Min. 250%
3.	Aging at 100°C for 72 hours								
	Tensile strength, initial value change %	+5.14	-22.72	+5.17	+9.65	+13.09	+21.05	Max. ± 30	Max. ± 30
	Elongation at break, initial value change %	+4.76	0.00	+23.80	-3.84	-14.28	-18.51	Max. -35	Max. -35

Table 2. Test results for LPG thermoplastic elastomer hose (tensile strength, elongation at break, and aging parameters)

No.	Test	Test result for Thermoplastic elastomer hose X		Test result for Thermoplastic elastomer hose Y		Quality Requirement in SNI 8022:2014	
		Inner	Outer	Inner	Outer	Inner	Outer
1.	Tensile strength, MPa	14.3	13.0	17.1	15.5	Min 10 MPa	Min 10 Mpa
2.	Elongation at break, %	320	330	290	320	Min. 200%	Min. 250%
3.	Aging at 100°C for 72 hours						
	Tensile strength, initial value change %	+6.29	+5.38	+2.33	-2.58	Max.-25	Max.-25
	Elongation at break, initial value change %	-3.12	-6.06	-3.44	+9.37	Max. -50	Max. -50

Discussion

In this research, testing of rubber hose and thermoplastic elastomeric hose has been carried out to see whether they fulfill the test requirements for tensile strength, elongation at break, and aging. Tensile strength is the amount of load required to stretch the LPG hose test sample until a breaking condition occurs. The tensile strength is an important factor because it shows the strength of rubber vulcanization (Daud, 2015). Elongation at break is the increase in the length of the LPG hose test sample when it is stretched to the breaking condition (in percentage of test sample length before stretching). The elongation at break test is useful to determine what percentage of the length of a test object/sample of rubber product increases when it is pulled until it breaks (Harahap & Buki, 2020). Aging is a change in the physical properties of a polymer over time caused by heat, oxygen, and mechanical pressure (Scully, 2013). This results in a decrease in the physical properties of rubber products. Aging will affect physical durability, so that finished rubber goods cannot last long (Marlina et al., 2014; Pertiwi et al., 2021). Overall, the test results for LPG rubber hose and LPG thermoplastic elastomer hose show that the test results meet the requirements of SNI 7213:2014 Rubber hose for LPG gas stove (Table 1) and SNI 8022:2014 Thermoplastic elastomer hose for LPG gas stove (Table 2)

Based on Table 1 and Table 2, it can be seen that 100% of the samples of LPG rubber hose and LPG thermoplastic elastomer hose passed the quality requirements of SNI 7213:2014 and SNI 8022:2014 for the parameters of tensile strength, elongation at break, and aging. However, the tensile strength test on rubber hose C shows a value of 7.6 Mpa (outer), where the test result value is close to the minimum tensile strength limit in SNI 7213:2014 (minimum value of 7 Mpa). Besides that, the tensile strength of rubber hose C (inner) and rubber hose A (outer) shows a value of 8.4 MPa and 8.8 MPa, which is a value that is slightly higher than the minimum limit value required by SNI. Even though this value is still above the minimum tensile strength limit required by SNI, corrective actions are needed, especially for the quality of rubber hose C to reach a more optimal value. The greater the tensile strength of test sample, it will indicate that the test sample is more elastic (Basseri, 2005). If a product becomes more elastic, the product will be more resistant to cracks that can occur (Hasan et al., 2019; Liu et al., 2023). So that LPG hose leaks due to bending cracks can be avoided and the potential risk to consumers of fire hazards can be minimized.

In the process of making LPG rubber hose, natural rubber must be made into a compound first. Compound is a homogeneous mixture of rubber and certain chemicals that has not undergone a vulcanization process. Compound making is necessary because natural rubber as a raw material for LPG hoses generally has properties that are not resistant to hydrocarbons and ozone, so a mixture of rubber compound materials that are resistant to hydrocarbons and ozone is used, for example Styrene Butadiene Rubber (SBR), NBR (Nitrile Butadiene Rubber), and EPDM (Ethylene Propylene Diene), PU (Polyurethane), etc. Different types of compound materials will result in differences in the physical and mechanical properties of the finished rubber product (Tampubolon et al., 2021). When used, rubber compounds often experience damage, including hardening and reduced elasticity. This depends on the conditions of use, which can affect the quality and shelf life of rubber products (Prasetya, 2016). Polyurethane (PU) is a type of compound-making material that has the best tensile strength when compared to SBR, NBR, and EPDM. Fillers also have an important role in making rubber compounds because they can make the vulcanisate harder and stiffer (Basseri, 2005). Fillers are supporting materials with the largest portion in the manufacture of rubber compounds. It is used to increase physical properties, improve processing characteristics and reduce costs (Harahap & Buki, 2020). Fillers in making rubber compounds can increase hardness, tear resistance, abrasion resistance, and tensile strength in finished rubber products. However, adding an inappropriate amount of filler in the rubber compound can also reduce the tensile strength value, because not all fillers can bind to the rubber molecules, resulting in aggregates that stick together (Herminiwati & Yuniari, 2010). Fillers used in making rubber compounds include aluminum silica, magnesium silica, carbon black, calcium carbonate, magnesium carbonate, kaolin, etc. Increasing the physical properties of the filler material is also influenced by the optimum amount of filler material and the strengthening of the filler material (grain size and fineness) (Daud, 2015). It is hoped that through improvements in the materials for making rubber compounds and the addition of optimal filler materials, the tensile strength of the rubber hose can be increased so that the optimum tensile strength value can be achieved.

Based on Table 2, it can be seen that the results of the tensile strength test on LPG thermoplastic elastomer hoses X and Y show values above the minimum tensile strength value required by SNI 8022:2014 (10Mpa). Thermoplastic elastomers can be processed into products using injection molding techniques which are different from rubber products which use a chemical vulcanization process and without the addition of fillers. Thermoplastic elastomer products have better physical properties compared to rubber products, including high tensile strength, high resilience, and high reversible elongation (Holden et al., 1969). So LPG hoses made from thermoplastic elastomers will have much better tensile strength compared to LPG hoses made from rubber.

For the elongation at break test, rubber hose C (inner part) shows a value of 200% which is the minimum limit value for elongation at break (inner and outer) required in SNI (Table 1). This shows that rubber hose C really needs quality improvement so that the elongation at break value can exceed the minimum limit required by SNI. Besides that, rubber hose A and rubber hose B also show an elongation at break value (inner and outer) which is slightly greater than the minimum limit value required by SNI. If we look at the results of the tensile strength and elongation at break tests which have been carried out on LPG rubber hoses and elastomeric thermoplastic hoses, the tensile strength value is inversely proportional to the elongation at break. This is because materials with a lower tensile strength typically have a higher elongation at break values (Hazirah et al., 2018; Kristiani, 2015). The addition of fillers such as carbon black in the rubber compound manufacturing process will have a strengthening effect on the rubber molecules so that it can increase the elongation at break of the resulting rubber compound (Harahap & Buki, 2020). LPG thermoplastic elastomer hoses generally have an elongation at break value that is higher than the minimum limit required by SNI. Elongation at break is a measure of the increase in length of a rubber compound piece when stretched until it breaks, expressed as a percentage of the length of the test piece before stretching (Rahmaniar, 2012). SNI requires that the elongation at break test results must be at least 200%. If a tensile force is applied to the LPG hose, it is expected to be able to stretch/elongate with a length increase of at least 2 times the initial length of the LPG hose (200%) without breaking. This means that when the LPG hose used by consumers experiences excessive tensile force, the product does not break easily so the potential for LPG gas leaks which can cause fires can be avoided.

In this research, testing was also carried out for aging at 100^{o}C for 72 hours. Based on table 1 and Table 2, it can be seen that the aging test result of all LPG rubber hoses and thermoplastic elastomer hoses meet the maximum limit value requirements in SNI. The values of the aging test results for LPG rubber hoses and LPG thermoplastic elastomer hoses are also far from the maximum limit values required by SNI. From Table 1 and Table 2, it can also be seen that the aging test results for LPG thermoplastic elastomer hoses are better when compared to LPG rubber hoses. Under ideal conditions, thermoplastic products have good chemical resistance (Setiorini, 2019). The manufacture of thermoplastic products is carried out in several ways depending on the type and concentration of the forming polymer, compatibilizer, filler, and other additives (Setiorini, 2019). The manufacture of TPE hose uses different raw materials (rubber and plastic) as well as additional materials (additives), including heat stabilizers, antioxidants, ultraviolet stabilizers, and colorants (Mujiarto, 2005). Resistance to aging can also be influenced by the addition of colorants. This is because colorants can affect the resistance of plastic products to heat and chemicals (Mujiarto, 2005). The use of colorants is indicated to increase the aging resistance of thermoplastic elastomeric hoses better than rubber hoses.

Conclusions

The LPG rubber hose test results show that rubber hose C has a tensile strength of 7.6 Mpa and an elongation at break of 200%. These test results were close to the maximum/minimum limits of the established SNI quality requirements (tensile strength of 7 Mpa and elongation at break of 200%). This indicates the need for corrective action to be taken by LPG hose manufacturers so that the LPG hose quality can reach optimal value. The greater the tensile strength of the LPG hose, it will indicate that the test sample is more elastic and more resistant to cracks. The greater the elongation at break of the LPG hose, it is expected that the LPG hose which experiences excessive tensile force can stretch at least 2 times the initial length of the LPG hose (200%) without breaking. So that LPG hose leaks due to bending cracks and excessive tensile force can be avoided and the potential risk to consumers of fire hazards can be minimized. To increase the tensile strength of LPG rubber hoses, this includes improvising rubber compound-making materials and adding optimal filler materials. To increase elongation at break of LPG rubber hoses, this can be done by adding carbon black as a filler in making rubber compounds. For LPG thermoplastic elastomer hoses, all tensile strength, elongation at break, and aging test values are still above the maximum/minimum quality requirements contained in SNI. Through the corrective actions taken, it is hoped that it will be able to increase the fulfillment of rubber hose quality requirements so that it can guarantee consumers from potential dangers that may arise.

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