TECHNICAL BULLETIN

PROGRESSING CAVITY PUMPS | LS-TB-013

LIFTING SOLUTIONS

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LS-TB-013 V1	HN2 ELASTOMER DEVELOPMENT	JUNE 27, 2020	ENGINEERING

BACKGROUND

LSI's initial high nitrile (HN1) elastomer design requirements and associated formulation development in 2017/2018 was constrained by limited materials laboratory testing capabilities as well as the absence of LSI product experience. Accordingly a cautious development and subsequent field deployment approach was taken with the intention of subsequently developing a second generation (HN2) material taking advantage of increased lab capabilities and application testing as well as field product experience with the original HN1 elastomer.

DEVELOPMENT OVERVIEW

Initial development work on HN2 started in January of 2019 with the addition of internal lab-scale elastomer mixing equipment, a rubber process analyzer and significantly expanded elastomer/bond fluid compatibility testing equipment. The mixing equipment enabled internal formulation development and the process analyzer an in-depth evaluation into the rheological and mechanical properties of the elastomer. Extensive fluid compatibility testing with elastomers and stator bond sections supported elastomer formulation refinement and bond process development. Multiple iteration cycles in the lab, during stator processing and on the durability bench enabled significant fine tuning of the HN2 formulation. Design requirements for the mechanical properties of the HN2 elastomer are compared between HN1 and HN2 in Table 1 below. Significant improvements with respect to the mechanical properties including elongation and tear strength have been addressed with formulation changes.

Physical Properties	Requirement	HN1	HN2
Hardness (Shore A)	70-75	71	73
Tensile Strength (psi)	3000-3500	2727	3152
Elongation at Break (%)	500	472	496
Tear Strength (lbf/in)	75	46	70

Table 1 – HN1 vs HN2, Mechanical Property Design Requirements

The mechanical property testing was done in conjunction with a comprehensive fluid compatibility test program. This included a range of standard test fluids and a numerous field fluids from the most challenging high nitrile applications. Table 2 and 3 provides a summary of the HN1 and HN2 elastomer volumetric swell test results (7 day with 2 mm thick specimens as per ISO 15136-1) for a sampling of standard test and field fluids. The HN2 elastomer has significantly lower swell in oils, especially those with higher API gravities and associated levels of aromatics. Water swell of HN2 is slightly higher due to a polymer change to a higher ACN level for oil resistance but most importantly swell with representive oil/water combinations is typically about one-half with HN2 versus HN1.

Fluid	Temperature	API Gravity	HN1	HN2
Water	100°C	n/a	4.8	6.5
Water	80°C	n/a	3.4	5.5
Water	60°C	n/a	3.2	4.1
IRM 903	100°C	23	6.2	-0.7
IRM 903	60°C	23	3.3	-1.2
Diesel	60°C	38	16.1	6.5
Fuel B	30°C	55	25.4	14

Table 2 – HN1 vs HN2, Compatibility Test Results with Standard Test Fluids

Fluid	Temperature	API Gravity	Water Cut (%)	HN1	HN2
C1F1	50°C	19	30	6.6	3.6
C1F2	50°C	21	80	4.9	2.7
C1F3	50°C	22	85	3.9	2.4
C1F4	50°C	21	97	3.5	2.2
C2F5	60°C	38	0	6.7	2.7
C3F6	50°C	26	70	5.5	3.0

Table 3 – HN1 vs HN2, Compatibility Test Results with Field Fluids

Another key focus of the product development was stator elastomer/tube bonding with a focus on improving unaged bond strength as well as aged bond strength when exposed to water and oil including at elevated temperatures. Testing focused on the evaluation of bond interface detachment during elastomer cutback on new/unused stators as well as QC bond pushout testing, water immersion, IRM 903 immersion and post durability bond evaluation. Table 4 summarizes the test results of HN2 compared to HN1 and demonstrates the improvements made particularly in terms of bond retention with water at elevated temperatures used to simulate extended exposure times.

Evaluation Criteria	HN1	HN2
New Cutback Evaluation	Absent	Absent
QC Bond Push Out	100% Rubber	100% Rubber
80oC Water Immersion	60-95% Rubber, 7 days	>90% Rubber, 28 days
100oC Water Immersion	0-50% Rubber, 7 days	>90% Rubber, 21 days
100oC IRM 903 Oil Immersion	100% Rubber, 7 days	100% Rubber, 7 days
85oC, 42 day Durability	Both passed KPI metrics with similar results.	

Table 4 – HN1 vs HN2, Stator Elastomer/Tube Bond Testing

CONCLUSION

After over 1 year of development including numerous formulation iterations (>100), Lifting Solutions has a high confidence its new HN2 elastomer represents significant improvements in terms of mechanical, swell resistance and bond integrity characteristics. Extensive lab testing as well as full-scale durability testing validated that the HN2 elastomer is ready for field deployment and installation monitoring. Application candidates similar to the ones from the field compatibility testing program along with others that challenged the operating envelope of the initial HN1 development are being identified for field testing.