LAPP GROUP

The Importance of Oil Resistant Cables

2010 Edition White Paper

By
John Gavilanes
Director of Engineering

LAPP USA ENGINEERING DEPARTMENT
LappUSAEngineering@LappUSA.com

The Importance of Oil Resistant Cables

Introduction

The demands of the industrial environment are on going, with ever changing trends. Cables, which were once able to sustain functional and operational integrity a decade ago, would not be adequate to survive in the environment of a present day manufacturing site. Everywhere, from the Renewable Energy Industry, Automotive Assembly Plants, to the factories that manufactures small office machines and even in some commercial buildings, the oil resistance of cables has become increasingly important. Oils serve a dual-purpose role in industrial applications, both as a coolant and lubricant, depending upon the requirements mandated by the end use application. Sustaining trouble free cable operation under harsh chemical and environmental conditions reduces costly manufacturing down time and helps to eliminate or minimize periodic maintenance and costly cable replacement. All of these factors mentioned play a major role that is critical to a consistent, smoothly run manufacturing operation, which in the end, results in higher profit margins.

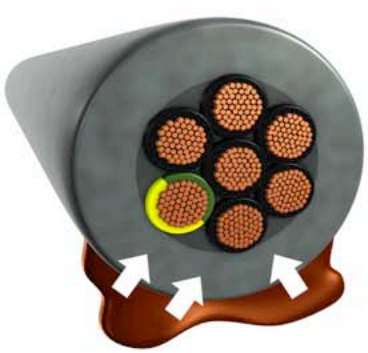
Regulatory and Code Changes

With the changes to the National Electrical Code (NEC) in the past 10 years, protective conduit or raceway is no longer required when running an exposed run (-ER) cable from the tray to the equipment or device. Previously, when the cable was extended from tray to machine, conduit or raceway was used primarily as a protection mechanism in helping to prevent cable damage. Originally TC-ER cable (previously printed “open wiring”) had a length limitation of 50 ft. from the tray to the equipment. The 50 Ft. allowances resolved a large “grey” area in the industrial environment and was initially a well-received solution by the industry. Due to the overwhelming acceptance of the 50 ft. length allowance, the NEC committee enacted further changes shortly thereafter, permitting unlimited length of TC-ER under Article 336. With the advent of unlimited length, Article 336 also brought other issues, like a greater area of cable exposure and susceptibility to the surrounding industrial environment. Under the typical conditions of operation, consideration for factors such as ambient temperature, a cables mechanical strength, unintended movement and constant exposure to industrial lubricating and coolant oils must be taken into account. When exposed to these conditions, the cable inevitably will begin to deteriorate; the overall jacket may swell and/or crack, creating a potentially hazardous condition, along with machine and production down time. These possible problems are undesirable and necessitate the need to implement cable protection measures. When referring to NFPA 79, the electrical standard for industrial machinery, Machine Tool Wire (MTW) is one type of cable permitted. Under the standard for machine tool wire, UL 1063, passing the Oil Res I test is required and further severe testing such as the Oil Res II is optional. Environmental resistance tests, such as those per UL Standards were implemented in response to the globalization of industry with the goal of standardizing the oil resistance requirements of cables used in manufacturing industrial machinery throughout the world.

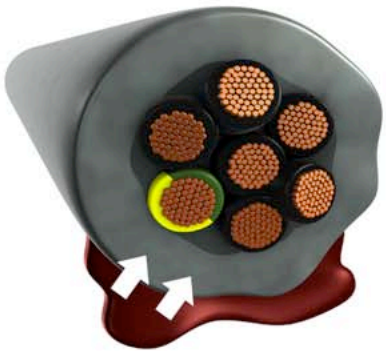
Purpose and Application

Why does oil cause such excessive damage on certain types of insulations and jackets and how does this occur? All compounds are not the same, for example, certain types of PVC have a higher degree of flame resistance, while others have better oil resistance, and some demonstrate improved flexibility characteristics. PVC formulations vary greatly, depending on the desired properties and applications. These properties can be achieved by adjusting the formulations of a particular PVC compound. The modification or addition of flame-retardants (iodine), stabilizers, and fillers allow the compound to exhibit these types of enhanced characteristics. However, when certain PVC characteristics are improved, the enhancement sometimes comes at a cost, the cost being that other performance traits are affected or completely lost.

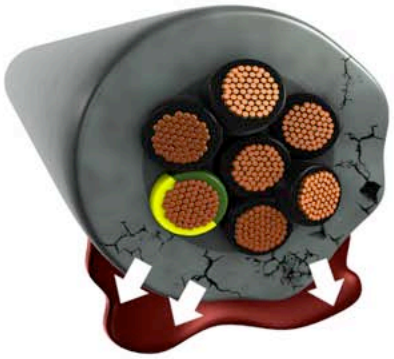
The specific application will determine if oil is used as a lubricant and/or coolant. Acting as a lubricant, oil would be applied to a gear system driven by motors to prevent premature wear down and insure smooth operation. Acting as a coolant, oil is applied during the machine lathing process to keep metal from becoming too hot. In the field, cables can be exposed to oil in a Wind Turbine nacelle, (the nacelle is the area located on the top of the turbine) where oil is used in the gearbox. Cables that lay in the floor of the nacelle are subjected to oil that is unavoidably spilled. These cables are then exposed to oil for very long periods of time, along with other extreme high and low temperatures causing the lower quality jacket compounds of a cable to crack. There are many factors involved regarding how oil will attack wire and cable, such as, exposure, ambient temperature and also possible continued immersion. In general, increases in the amount of exposure, the frequency and the ambient temperature, the faster oil will start the deterioration process. In short, oil attacks the insulating compound, where it will become virtually ineffective in its primary role as an effective insulator. This action can create a possibly very hazardous situation, not only to human life, but also to the overall function of the industrial machinery to which it is connected. This results in very expensive downtime, costly repair and in the worst-case scenario, entire replacement of the machine.



Step 1: When process oils come in contact with PVC & Polyolefin compounds, the process oils are attracted to the plasticizers in the cable.



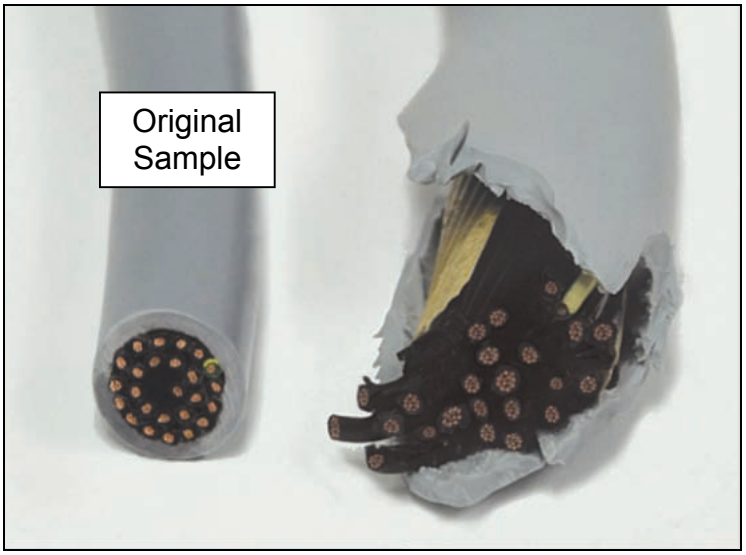
Step 2: The oils can be absorbed by a Polyolefin material resulting in swelling and weakening of the cable jacket.



Step 3: The oils can extract the plasticizers from PVC materials making the cable jacket hard and lead to failures.

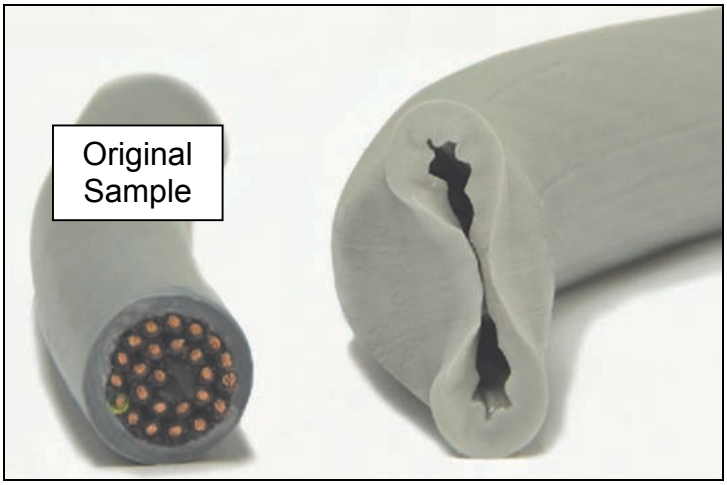
What Happens

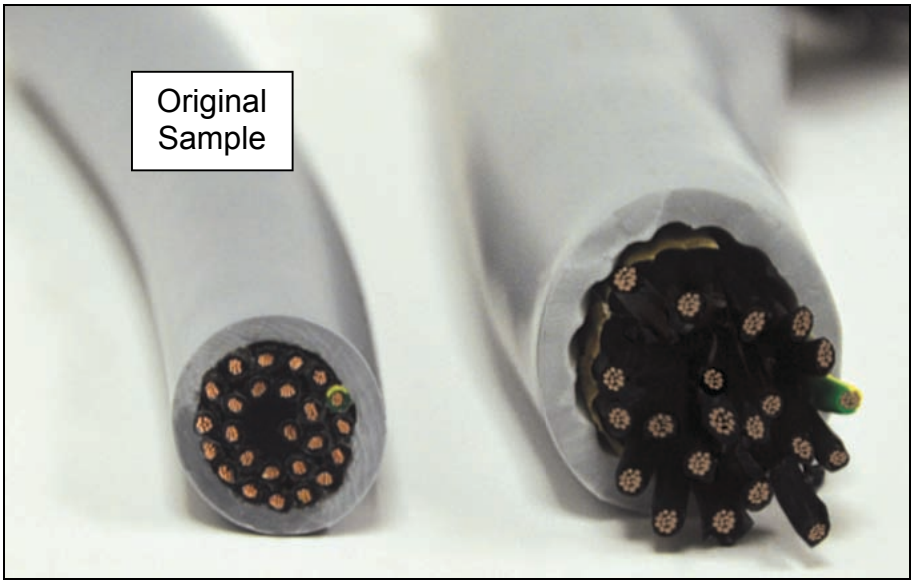
All wire and cable insulations are not created equal. Electrical, environmental, mechanical, and chemical attributes will vary depending upon the individual compound formulations. Insulating compounds contain a specific amount of plasticizers in their individual formulations, which help promote flexibility and resistance to fatigue. When compounds are exposed to lubricating and coolant processing oils the material either absorbs the oil or the plasticizer will diffuse from the compound. When oil is absorbed, it causes severe swelling and softening of the compound resulting in degradation of tensile properties. When the oil causes diffusion of the compound plasticizer, hardening will result and all flexibility and elongation properties are lost. The attached pictures will illustrate the effects that oil can inflict on cable jackets and insulation:



Cracking – Caused during exposure of the PVC to oil or other chemicals due the complete removal of plasticizers, resulting in hardening and eventual cracking of the insulation and jacket.

Melting – Caused during exposure of the PVC to oil or other chemicals due to the absorption and combination with the plasticizer, resulting in softening and the high elasticity noted in the compound.





Swelling – Caused during exposure of the PVC to oil or other chemicals due to migration of the oils into the plasticizer, resulting in noticeable increases in insulation and jacket diameter.

Discoloring – Caused during the exposure of the PVC to oil or other chemicals due to the diffusion of the plasticizers along with colorant from the insulation and jacket.

The preceding pictures verify the damage caused by oil exposure is irreversible and creates hazardous conditions. Now, in addition to cable replacement costs, there is also the expense of reinstallation to be taken into account. To avoid these types of unwanted scenarios, the customer must review the properties of the cables they are about to consider for their application and determine suitability for the oil environment. There are UL tests, which help determine how a cable will react in the industrial oil environment. These tests are more commonly referred to as the Oil Res I and Oil Res II tests, which involve continuous immersion of the cable samples in IRM 902 at elevated temperatures for a specified period of time. Passing results are determined by the evaluation of mechanical properties and observations of physical damage caused by the oil exposure. In 2000, Lapp as an innovator and leader, approached UL about creating tougher standards which resulted in the creation of AWM style 21098.The table below indicates the industry standard tests that are used to evaluate wire and cable oil exposure performance:

Industry Oil Exposure Tests

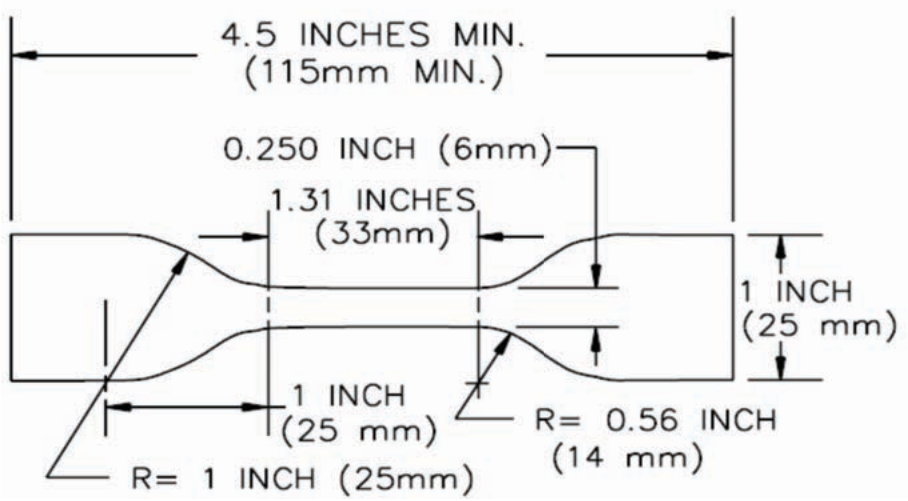
Name	Method	UL Requirement
UL 62	Oil Immersion for 7 Days @ 60°C	75% retention of unaged tensile and elongation
UL Oil Res I	Oil Immersion for 4 Days @ 100°C	50% retention of unaged tensile and elongation
UL Oil Res II	Oil Immersion for 60 Days @ 75°C	65% retention of unaged tensile and elongation
UL AWM 21098	Oil Immersion for 60 Days @ 80°C	65% retention of unaged tensile and elongation

Example of Tensile and Elongation Test Methods

Let us assume, for example, that the cable jacket of your product is going to be tested for compliance to UL Oil Res II. Tensile and Elongation tests must be performed both on the original (unaged) and oil immersed (aged) test samples and must be prepared as defined under UL Standard 2556. Die cut dumbbell specimens are taken from the jacket and are then tested for tensile strength and elongation.

As for sample preparation, two marks are applied approximately 1.3 inches apart from each other and equidistant from the center of the dumbbell sample. (See diagram on next page). These marks are applied at right angles to the direction of the pull in the testing apparatus. The sample is then clamped on the tester with one-inch marks outside of and between the grips. The grips are then separated at the rate of 20 inches per minute until the sample breaks. Results are then recorded for elongation and pound force breakage; tensile strength is calculated by dividing the pound force by the cross sectional area of the specimen.

Die-Cut Specimen



Untested die cut samples are aged under the UL Oil Res II requirement of 75°C for 60 days. After 60 days, the samples are removed from the oil for a minimum of 16 hours. They are then tested for tensile and elongation, which must retain 65% of the unaged values. The following is an example for an Oil Res II test results:

Sample	Tensile Strength (PSI)	Elongation (%)	Tensile Retention (%) Pass / Fail	Elongation Retention (%) Pass / Fail
Original	3698	167	--------	--------
Aged	3625	129	98 / Pass	77 / Pass

Oil Res II Test Requirement: **65% of the original tensile and elongation values**
65% (3698 Psi) = 2404 Psi, min. 65% (167%) = 109%, min.

Unaged Tensile Strength: 3698 Psi
Aged Tensile Strength: 3625 Psi

Percent Retention: $\frac{3625\ Psi}{3698\ Psi} \times 100 = 98\%$

Unaged Elongation: 167%
Aged Elongation: 129%

Percent Retention: $\frac{129\%}{167\%} \times 100 = 77\%$

Conclusion

The oil resistance of cables has now become a critical performance parameter when electrical contractors, engineers, and installers specify cables for end use application designs. The continued growing popularity of oil resistance requirements is due to changes in standard regulations and the increased performance characteristics that are mandated by certain industries: Renewable Energy, Automotive Assembly Plants and other production facilities. As time moves forward, superior oil resistant cables will become standard, rather than the exception and the demand for this type of operating performance will only continue to grow.

The Lapp Group is a family run company that provides cable products, not only in North America, but also throughout the entire world. We have established a laboratory in the US that is devoted entirely to the testing, research and development of wire and cable. Brand new state of the art equipment provides the highest degree of accuracy and insures that all tests performed are compliant with the rigid performance requirements mandated by UL Standards. The laboratory has attained acceptance to the UL Client Test Data Program. This is a milestone that is unique in the wire and cable industry. The Lapp Group's laboratory is another distinctive element, which helps to exemplify our commitment to providing products that are designed and tested to a higher standard. All of these factors show why Lapp is known as the leader in the wire and cable industry.

The Lapp Group has been providing oil resistant wire and cable products for the past 50 years and will continue being the industry leader in the future. Lapp Group is ahead of the pack and has already made the commitment to service industries that are directly affected by these new oil resistant requirements. The numerous cable designs within our product family groups offer varying degrees of oil resistance combined with other premium characteristics to better serve the needs of industry today and in the future. Please see the next page for cables offered by Lapp Group that provide varying degrees of protection for any industrial environment.

LAPP GROUP PRODUCTS

Product Name	Description	UL / CSA Approvals	UL Oil Res. I	UL Oil Res. II	-25ºC Cold Impact	-40ºC Cold Impact	FT4 Flame
ÖLFLEX® 190 & ÖLFLEX® 190 CY	Power & Control Cable for Machinery	MTW / 600V - AWM	X	X			
ÖLFLEX® FD 890 & ÖLFLEX® FD 890 CY	Power & Control Continuous Flexible Cable for C-track	600V - AWM	X	X			
ÖLFLEX® TRAY II & ÖLFLEX® TRAY II CY	Power & Control Tray Cable	MTW 600V - TC & CIC/TC	X		X		X
ÖLFLEX® TC 600 & ÖLFLEX® TC 600S	Power & Control Tray Cable	600V - TC & CIC/TC	X		X		X
UNITRONIC® 300 & UNITRONIC® 300S	Multi Conductor Control Cable	300V / CMG	X		X		X
ÖLFLEX® FORTIS	Power & Control Tray Cable	MTW 600V - TC & CIC/TC	X	X	X	X	X
ÖLFLEX® CONTROL TM & ÖLFLEX® CONTROL TM CY	Power & Control Tray Cable	MTW 600V - TC & CIC/TC	X		X		X
ÖLFLEX® VFD Slim	Power VFD Cable	MTW 600V- TC & CIC/TC	X		X		X
ÖLFLEX® POWER IX	Power & Control Cordage	600V SOOW / HAR	X*				
ÖLFLEX® POWER QUAD II	Power & Control Cordage	300V SJTO / HAR	X	X			
ÖLFLEX® VFD with Brake	Power VFD Cable with 1 Pair for Brake	MTW 600V - TC & CIC/TC	X	X	X		X
ÖLFLEX® VFD Symmetrical	Power VFD Cable	MTW 600V - TC & CIC/TC	X		X		X
ÖLFLEX® FD VFD	Power VFD Cable for Continuous Flexible for C-track	600V - TC & CIC/TC	X	X	X		X
ÖLFLEX® CHAIN 879 & ÖLFLEX® CHAIN 879 CY	Power & Control Tray Cable for Continuous Flex	MTW 600V - 1000V - AWM	X	X			
ÖLFLEX® POWER MULTI	Power & Control Tray Cable and Extra Hard Usage Cordage	STOOW 600V - TC & CIC/TC	X	X	X		X
ÖLFLEX® AUTO I	Power & Control Tray Cable	600V - TC & CIC/TC	X		X		X
ÖLFLEX® AUTO X	Power & Control Tray Cable	600V - TC & CIC/TC	X	X	X		X

* Passes UL 62 Oil Resistance Test

NEC Interpretation

As a customer courtesy, when requested, we at Lapp Group will at times provide our opinions regarding interpretation of NEC articles. It is very important to remember that these are our opinions only; as a manufacturer of wire and cable we are not a "jurisdictional authority". Opinions expressed by Lapp concerning NEC article interpretations are never to be construed as a "guide" or "advice" depicting specific approved installation wiring methods and cable requirements. Only the Authority Having Jurisdiction (AHJ) can provide the final determination and approve equipment, materials, an installation or wiring procedure that will comply with NEC requirements. An interpretation of NEC code regulations by the AHJ is the only decision maker regarding any electrical installation in the US; however be advised that AHJ decisions can vary between the individual states and local municipalities. Before any installation, we recommend and highly advise to contact the AHJ in your area regarding any questions concerning specific NEC installation requirements or approved wiring methods before committing to any cable purchase.

Definitions

Industrial Machine – A power driven machine (or a group of machines working together in a coordinated manner), not portable by hand while working, that is used to process material by cutting, forming, pressure, electrical, thermal, or optical techniques, lamination, or a combination of these processes. It can include associated equipment used to transfer material or tooling, including fixtures, to assemble/disassemble, to inspect or test, or to package.

Machine Tool Wire – Thermoplastic wire or cable for use as specified in the National Electrical Code (NFPA 70) and in the National Fire Protection Association Electrical Standard for Industrial Machinery (NFPA 79).

NFPA 70 – The National Electrical Code (NEC) is a standard, which covers the installation of electrical conductors, equipment, and raceways; signaling and communication conductors, equipment, and raceways; and optical fiber cables and raceways for residential premises, commercial buildings, and industrial facilities. This code is not intended as a design specification or an instruction manual for untrained persons.

NFPA 79 – The Electrical Standard for Industrial Machinery, a standard, which provides detailed information for the application of electrical/electronic equipment, apparatus, or systems supplied as part of industrial machines that will promote safety to life and property. The provisions of this standard apply to the electrical/electronic equipment, apparatus, or systems of industrial machines operating from a nominal voltage of 600 volts less, and commencing from the point of connection of the supply to the electrical equipment of the machine.

Oil Res I Test – UL test which determines oil resistance of wire and cable under test conditions of complete immersion in IRM 902 oil for a period of 4 days at a temperature of 100°C. Requires 50% retention of the original values obtained for tensile and elongation, this test is a requirement for any wires or cables that are manufactured to UL 1063.

Oil Res II Test – UL test which determines oil resistance of wire and cable under test conditions of complete immersion in IRM 902 oil for a period of 60 days at a temperature of 75°C. Requires 65% retention of the original values obtained for tensile and elongation, this test is an optional requirement for any wires or cables that are manufactured to UL 1063, but is required now as a standard oil test for the Wind Turbine Industry.

GERMAN PRECISION ENGINEERING PROUDLY PRODUCED IN THE USA.

The Lapp Group North American headquarters located in Florham Park, NJ houses Lapp USA, Lapp Cable Works and our latest expansion, Lapp Group's Center for Competence and Innovation. This Center is assessed by UL as a Client Test Data Program (CTDP) laboratory for Product Testing, R&D, Quality Validation and New Product Innovation. Lapp Cable Works is our state of the art cable manufacturing plant for ÖLFLEX® brand quality products and custom designed cables. In addition, this facility houses Lapp Systems, which provides complex harnesses, integrated solutions and custom cable assemblies.

2,600 PEOPLE, 21 LANGUAGES 1 WORLDWIDE FAMILY

In the late 1950's, Oskar Lapp turned his visionary dream into reality with the invention of the first industrially manufactured control cable, ÖLFLEX®. This was the beginning of his family run and oriented company. Lapp Group produces innovative cables, connectors, accessories, and engineered solutions as a worldwide market leader. Oskar Lapp's vision continues today through his wife, Ursula Ida, and his sons, Andreas and Siegbert Lapp.

Within 50 years, the Lapp Group has grown to 2,600 employees operating around the globe developing, manufacturing and selling more than 40,000 products. With 17 manufacturing sites, 39 company-owned sales operations, more than 100 foreign representations and worldwide headquarters in Stuttgart, Germany, the Lapp Group people are everywhere you need us to be.

ÖLFLEX®
Power & Control Cables

SKINTOP®
Cable Glands

SILVYN®
Conduit

ETHERLINE®
Industrial Ethernet

EPIC®
Connectors

UNITRONIC®
Data Cables

FLEXIMARK®
Marking Systems

HITRONIC®
Fiber Optic Cables

LAPP GROUP

LAPP USA
29 Hanover Road
Florham Park, NJ 07932
800-774-3539
www.lappusa.com

LAPP CANADA
3505 Laird Road, Unit 10
Mississauga, Ontario L5L 5Y7
877-799-5277
www.lappcanada.com

LAPP MEXICO
Metalurgia 2730
Alamo Industrial, C.P. 44490
Tlaquepaque, Jalisco
800-024-5277
www.lappmexico.com

July 2010, Rev 1