Inspector 400 Ultrasonic Probe
Model CMIN400

P/N 32183800
Revision A

⚠ ***WARNING!*** Read this manual before using this product. Failure to follow the instructions and safety precautions in this manual can result in serious injury. Keep this manual in a safe location for future reference.

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Please take a moment to register your product at www.skf.com/cm/register to receive exclusive benefits offered only to our registered customers, including receiving technical support, tracking your proof of ownership, and staying informed about upgrades and special offers. (Please visit our website for more details on these benefits.)

Tell us how we're doing!

It's important that you're satisfied with the quality of our product user manuals. We appreciate your feedback; if you have comments or suggestions for improvement, please tell us how we're doing!

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SKF Reliability Systems Limited Warranty

WARRANTY

Subject to the terms and conditions contained herein, SKF warrants to the Buyer that for the warranty period indicated below the products sold by SKF that are listed below (the "Products"), when properly installed, maintained and operated, will be free from defects in material and workmanship and shall be fit for the ordinary purposes for which the Products are designed.

BUYER'S LIMITED REMEDIES

This limited warranty defines SKF's sole and exclusive liability and Buyer's sole and exclusive remedy for any claim arising out of, or related to, any alleged deficiency in any Product sold by SKF, even if such claim is based on tort (including negligence or strict liability), breach of contract, or any other legal theory.

If the Product does not conform to this limited warranty, Buyer must notify SKF or SKF's authorized service representative within thirty (30) days of discovery of the nonconformity; provided, however, that SKF shall not be liable for any claim for which notice is received by SKF more than thirty (30) days following the expiration of the applicable warranty period for the Product. Upon receipt of timely notification from Buyer, SKF may, at its sole option, modify, repair, replace the Product, or reimburse Buyer for any payment made by Buyer to SKF for the purchase price of the Product, with such reimbursement being pro rated over the warranty period.

WARRANTY PERIOD

Except as expressly provided below, the warranty period for each Product shall commence on the date the Product is shipped by SKF to Buyer.

90-DAY WARRANTY

Products warranted for ninety (90) days by SKF are as follows: cable assemblies, MARLIN QuickConnect (MQC), magnetic temperature probes, and all refurbished equipment.

ONE-YEAR WARRANTY

Products warranted for one (1) year by SKF are as follows: all Microlog products and accessories, all MARLIN data managers (MDM), all MARLIN Condition Detectors (MCD), all Wireless Machine Condition Detectors (WMCD), all Multilog Condition Monitoring Units (CMU, TMU), Multilog Local Monitoring Units (LMU), all Wireless Monitoring Systems V/T, all Vibration PenPlus, all Machine Condition Advisors (MCA), all transmitters, all SKF software, all Monitor Interface Modules (MIM), all Machine Condition Transmitters (MCT), MicroVibe P and Custom Products with the prefix of CMCP (with the exception of any consumable or expendable items).

TWO-YEAR WARRANTY

Products warranted for two (2) years by SKF are as follows: all standard Eddy Probes, Eddy Probe Drivers, and Eddy Probe Extension Cables, Multilog On-line Monitoring system (DMx), and all M800A and VM600 Machinery Monitoring Systems.

For all On-line Systems that have satisfied Criteria 1 and 2 below, the warranty period shall be either thirty (30) months from the date the On-line System is shipped by SKF to Buyer, two (2) years from the date the On-line System is installed and commissioned by SKF, or two (2) years from the date on which the installation of the On-Line System has been audited and commissioned by SKF or its authorized service representative, whichever period ends first.

Criteria 1.

Devices used with a Multilog Condition Monitoring Unit (CMU), Multilog Local Monitoring Unit (LMU), including, but not limited to, the sensing device, the interconnect cabling, junction boxes, if any, and the communications interface, must consist only of SKF-supplied or SKF-approved devices and/or components. The computer provided by Buyer must meet the requirements stipulated by SKF.

Criteria 2.

SKF or its authorized service representative has installed the On-line System or has audited the installation and commissioned the On-line System.

“On-line Systems” are defined as systems consisting of Multilog Condition Monitoring Unit(s) (CMU), Multilog Local Monitoring Unit(s) (LMU), and any sensing or input devices, the interconnect cabling between the sensing or input devices and the Multilog Condition Monitoring Unit(s) (CMU), Multilog Local Monitoring Unit(s) (LMU), and the cabling between the Multilog Condition Monitoring Unit (CMU), Multilog Local Monitoring Unit (LMU) and the proprietary SKF communications interface with the host computer.

FIVE-YEAR WARRANTY

Products warranted for five (5) years by SKF are as follows: all standard seismic sensors (accelerometers and velocity transducers).

OTHER SKF PRODUCTS

Any SKF product supplied hereunder but not covered by this limited warranty shall be either covered by the applicable SKF limited warranty then in place for such product or, if no such warranty exists, shall be covered by the 90-day warranty stated above.

THIRD PARTY PRODUCT WARRANTIES

For any third party products sold to Buyer by SKF, SKF will transfer to Buyer any warranties made by the applicable third party product vendor to the extent such warranties are transferable.

CONDITIONS

As a condition to SKF's warranty obligations hereunder and if requested or authorized in writing by SKF, Buyer shall forward to SKF any Product claimed by Buyer as being defective. Buyer shall prepay all transportation charges to SKF's factory or authorized service center. SKF will bear the cost of shipping any replacement Products to Buyer. Buyer agrees to pay SKF's invoice for the then-current price of any replacement Product furnished to Buyer by SKF, if the Product that was replaced is later determined by SKF to conform to this limited warranty.

SKF shall not be obligated under this limited warranty or otherwise for normal wear and tear or for any Product which, following shipment and any installation by SKF (if required by the contract with the Buyer), has, in SKF's sole judgment, been subjected to accident, abuse, misapplication, improper mounting or remounting, improper lubrication, improper repair or alteration, or maintenance, neglect, excessive operating conditions or for defects caused by or attributable to the Buyer, including without limitation Buyer's failure to comply with any written instructions provided to Buyer by SKF.

SKF shall be free to conduct such tests, investigations and analysis of the Products returned to SKF, as it deems reasonable and proper in the exercise of its sole judgment. As a further condition to SKF's obligations hereunder, Buyer shall offer its reasonable cooperation to SKF in the course of SKF's review of any warranty claim, including, by way of example only, Buyer's providing to SKF any and all information as to service, operating history, mounting, wiring, or re-lubrication of the Product which is the subject of the Buyer's warranty claim.

EXCEPT WARRANTY OF TITLE AND FOR THE WARRANTIES EXPRESSLY SET FORTH IN HEREIN, IT IS UNDERSTOOD AND AGREED THAT: (a) SKF MAKES NO OTHER WARRANTY, REPRESENTATION OR INDEMNIFICATION, EITHER EXPRESS OR IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTY OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, OR NON-INFRINGEMENT; (b) IN NO EVENT SHALL SKF BE LIABLE OR OBLIGATED FOR SPECIAL, EXEMPLARY, PUNITIVE, INCIDENTAL, DIRECT, INDIRECT, GENERAL OR CONSEQUENTIAL DAMAGES (INCLUDING, BY WAY OF EXAMPLE ONLY, LOST PROFITS OR SAVINGS, LOSS OF BUSINESS OR LOSS OF USE) OR ANY OTHER LOSS, COST OR EXPENSE IN CONNECTION WITH THE PRODUCTS AND RELATED SERVICES, IF ANY, PROVIDED BY SKF, AND THIS DISCLAIMER SHALL EXTEND AS WELL TO ANY LIABILITY FOR NONPERFORMANCE CAUSED BY SKF'S GROSS OR ORDINARY NEGLIGENCE, AND IN ALL CASES REGARDLESS OF WHETHER OR NOT ANY OF THE FOREGOING WERE FORESEEABLE OR THAT SKF WAS ADVISED AS TO THE POSSIBILITY OF SUCH DAMAGES, LOSS, COST, OR EXPENSE; AND (c) NO PERSON HAS BEEN AUTHORIZED BY SKF TO MAKE ANY FURTHER OR CONTRARY INDEMNITIES, REPRESENTATIONS OR WARRANTIES ON BEHALF OF SKF. THE FOREGOING LIMITATIONS AND DISCLAIMERS OF LIABILITY SHALL BE MADE APPLICABLE TO THE

SALE OF ANY PRODUCT BY SKF TO THE FURTHEST EXTENT PERMITTED BY APPLICABLE LAW.

The exclusive remedies provided in this limited warranty shall not be deemed to have failed of their essential purpose so long as SKF is willing and able to perform to the extent and in the manner prescribed in this limited warranty.

CM-F0001
(Revision P, 12-07)

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Introduction

⚠ Safety Instructions

> ***⚠ WARNING! Improper use of your ultrasonic detector may result in death or serious injury. Observe all safety precautions. Do not attempt to make any repairs or adjustments while the equipment is operating. Be sure to turn off and lock out all electrical and mechanical sources before performing any corrective maintenance. Always refer to local guidelines for appropriate lockout and maintenance procedures.***

Safety Precaution

Although your ultrasonic instrument is intended for use while equipment is operating, the close proximity of hot piping, electrical equipment, and rotating parts are all potentially hazardous to the user. Be sure to use extreme caution when using your instrument around energized equipment. Avoid direct contact with hot pipes or parts, any moving parts or electrical connections. Do not attempt to check findings by touching the equipment with your hands or fingers. Be sure to use appropriate lockout procedures when attempting repairs.

Be careful with loose hanging parts such as the wrist strap or headphone cord when inspecting near moving mechanical devices since they may get caught.

Don't touch moving parts with the contact probe. This may not only damage the part, but cause personal injury as well.

When inspecting electrical equipment, use caution. High voltage equipment can cause death or severe injury. Do not touch live electrical equipment with your instrument. Use the rubber focusing probe with the scanning module. Consult with your safety director before entering the area and follow all safety procedures. In high voltage areas, keep the instrument close to your body by keeping your elbows bent. Use recommended protective clothing. Do not get close to equipment. Your detector will locate problems at a distance.

When working around high temperature piping, use caution. Use protective clothing and do not attempt to touch any piping or equipment while it is hot. Consult with your safety director before entering the area.

Overview

Ultrasound technology is concerned with sound waves that occur above human perception. The average threshold of human perception is 16,500 Hz. Although the highest sounds some humans are capable of hearing is 21,000 Hz, ultrasound technology is usually concerned with frequencies from 20,000 Hz and up. Another way of stating 20,000 Hz is 20 kHz, or kilohertz. One kHz is 1,000 Hz.

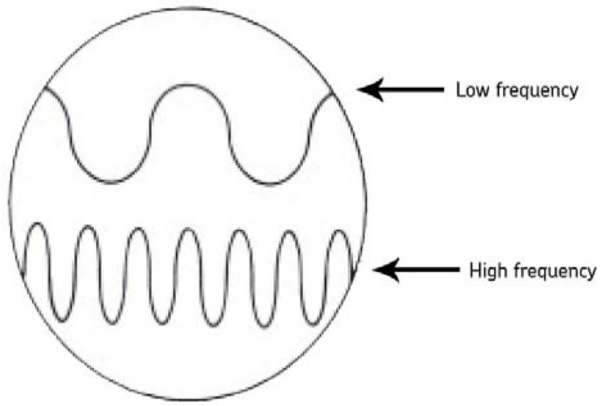

Figure 1. High and Low Frequency Comparison.

Since ultrasound is a high frequency, it is a short wave signal and the properties are different from audible or low frequency sounds. A low frequency sound requires less acoustic energy to travel the same distance as high frequency sound (Figure 1).

Ultrasound technology utilized by the Inspector 400 is generally referred to as airborne ultrasound. Airborne ultrasound is concerned with the transmission and reception of ultrasound through the atmosphere without the need of sound conductive (interface) gels. It can and does incorporate methods of receiving signals generated through one or more media via wave guides.

There are ultrasonic components in practically all forms of friction. For example, if you rub your thumb and forefinger together, you generate a signal in the ultrasonic range. Although you might be able to very faintly hear the audible tones of this friction, with the Inspector 400 it could sound extremely loud.

The reason for the loudness is that the Inspector 400 converts the ultrasonic signal into an audible range and then amplifies it. Due to the comparative low amplitude nature of ultrasound, amplification is a very important feature.

Although there are obvious audible sounds emitted by most operating equipment, it is the ultrasonic elements of the acoustic emissions that are generally the most important. For preventative maintenance, many times an individual listens to a bearing through some simple type of audio pick-up to determine bearing wear. Since that individual is hearing ONLY the signal's audio elements, the results of that type of diagnosis will be quite gross. The subtleties of change within the ultrasonic range will not be perceived and therefore omitted. When a bearing is perceived as being bad in the audio range it is in need of immediate replacement. Ultrasound offers a predictable diagnostic capacity. When changes begin to occur in the ultrasonic range, there is still time to plan appropriate maintenance. In the area of leak detection, ultrasound offers a fast, accurate method of locating minute and gross leaks. Since ultrasound is a short wave signal, the ultrasonic elements of a leak are loudest and most clearly perceived at the leak site. In loud factory type environments, this aspect of ultrasound makes it even more useful.

Most ambient sounds in a factory block out the low frequency elements of a leak and thereby render audible leak inspection useless. Since the Inspector 400 is not capable of responding to low frequency sounds, it hears only the ultrasonic elements of a leak.

By scanning the test area, a user may quickly spot a leak.

Electrical discharges, such as arcing, tracking, and corona, have strong ultrasonic components that may be readily detected. As with generic leak detection, these potential problems can be detected in noisy plant environments with the Inspector 400.

Specifications

Construction:	Hand held ABS pistol type ultrasonic processor stainless steel sensor enclosures
Circuitry:	SMD/Solid State hybrid hetrodyne receiver
Frequency Response:	20 to 100 kHz (centered at 38 to 42 kHz)
Indicator:	10 segment LED bargraph (red)
Sensitivity Selection:	8 position precision attenuation
Power:	9 volt alkaline battery (non-rechargeable)
Low Battery Voltage Indicator:	LED
Headset:	Double headset wired monophonic, Impedence: 16 ohms. Over 23 dB noise attenuation.
Response time:	300 m sec.
Ambient Operating Temperature Range:	0° to 50° C (32° to 120° F)
Relative Humidity:	10 to 95% noncondensing at up to 30° C (86° F)

Storage Temperature:	-18° to 54° C (0° to 130° F)
Dimensions:	5.5" x 2" x 8" (14 mm x 5 mm x 20 mm)
Weight:	11 oz.(310 gms)

Probes

Scanning Module (SCM-1):	Stainless Steel unisonic (single transducer) piezo electric crystal type
Stethoscope (contact) Module:	Stainless Steel plug-in type with 5.5" Stainless Steel waveguide
Rubber Focusing Probe:	Circular shaped, shields stray ultrasound signals, focuses detected signals
Carrying Case:	Cordura / Nylon with die cut foam
Warranty:	one year, parts / labor

The Inspector 400 provides easy, accurate leak detection and mechanical inspection through advanced ultrasonic technology.

Before you begin testing, it is advisable to familiarize yourself with the basic components of your kit.

Figure 2. Inspector 400 Kit Contents.

Pistol Housing

The main component of the Inspector 400 is the pistol housing. Let's define each part.

Bargraph Display - The display consists of a ten segment LED bargraph that indicates ultrasonic signal strength. A low number of LEDs indicate a low level of ultrasound; more intense ultrasonic signals display more LEDs.

Battery Level Light - This red light turns on only when the batteries need to be replaced.

- When the trigger on / off switch is pulled to the on position the Battery Level Light flickers on and then stays off. This is normal and has no relation to battery condition.

Sensitivity Selection Dial - There are eight sensitivity levels. As the dial is turned up, the sensitivity of the instrument increases; as the dial is turned down, the sensitivty decreases. Therefore, 8 is the highest sensitivity level and 1 is the lowest. When it is necessary to detect a low level ultrasound, start with the sensitivity at 8. If the ultrasound level to be sensed is too great, adjust the sensitivity level down.

Head Set Jack - This is where you plug in the headset. Be sure to plug it in firmly until it clicks. Should a tape recorder be utilized, this is where the cord for the tape recorder is inserted. (Use a miniphone plug.)

Trigger Switch - This is located on the underside of the Inspector 400. The Inspector 400 is always “off” until the trigger switch is pressed. To operate, simply press the trigger; to turn the instrument off, release the trigger.

Scanning Module

This module is utilized to receive air-borne ultrasound such as the ultrasounds emitted by pressure leaks and electrical discharges. To use, make sure it is plugged in to the front end of the metered pistol housing by aligning the plug with the receptacle and inserting it firmly.

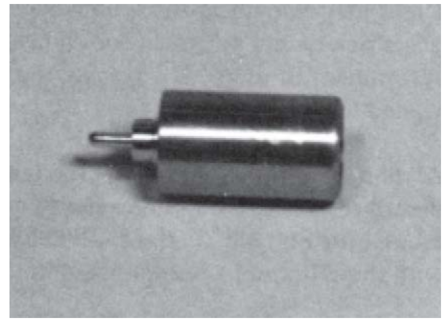

Figure 3. The Scanning Module.

To use the Scanning Module:

- Plug in to front end.
- Start with the sensitivity selection dial at maximum (8).
- Start to scan the test area.
- Measure from the "gross to the fine." If there is too much ultrasound in the area, reduce the sensitivity, place the Rubber Focusing Probe (described below) over the scanning module and proceed to follow the sound to the loudest point. If it is difficult to locate the sound due to a high intensity signal, keep reducing the sensitivity and follow the meter to the loudest point.

Rubber Focusing Probe - The Rubber Focusing Probe is a circular shaped rubber shield used to block out stray ultrasound, and to assist in narrowing the field of reception of the Scanning Module. It also increases the sensitivity. To use, simply slip it over the front of the scanning module or the contact module.

- To prevent damage to the module plug, always remove the scanning or contact module before attaching and removing the Rubber Focusing Probe.

Contact (Stethoscope) Module

The module with the metal rod. The rod is utilized as a “wave-guide” that is sensitive to ultrasound generated internally (such as within a pipe, bearing housing, steam trap or wall). Once stimulated by ultrasound, it transfers the signal to a piezoelectric transducer located directly in the module housing.

Figure 3. Scanning Module.

Figure 4. The Contact (Stethescope) Module.

To use the Stethoscope Module:

- Align the pin located at the rear of the module with the jack in the front end of the Pistol Housing and plug in firmly.
- Touch the test area.
- As with the scanning module, go from the "gross" to the "fine." Start at sensitivity on the Sensitivity Selection Dial and proceed to reduce the sensitivity until a satisfactory sound and meter level is achieved.

Headset

The headset allows the user to easily hear the sounds received by the Inspector 400. To use, simply plug the headset cord into the headset jack on the pistol housing, and place the headphones over your ears. A deluxe noise isolating type headphone CMAC8600-2 is available as an option and if a hard hat is to be worn, it is recommended to use the optional SKF model CMAC 8600-3 Hard Hat Headphones which are specifically designed for hard hat use.

2
Inspector 400 Applications

Leak Detection

This section covers airborne leak detection of pressure and vacuum systems. (For information concerned with internal leaks such as in valves and steam traps, refer to the appropriate sections.)

What produces ultrasound in a leak? When a gas passes through a restricted orifice under pressure, it is going from a pressurized laminar flow to low pressure turbulent flow (Figure5). The turbulence generates a broad spectrum of sound called “white noise.” There are ultrasonic components in this white noise. Since the ultrasound is loudest by the leak site, the detection of these signals is usually quite simple.

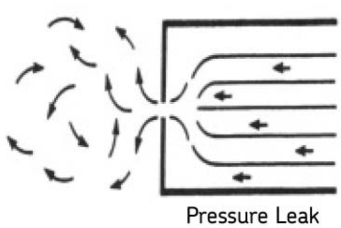

Figure 5.

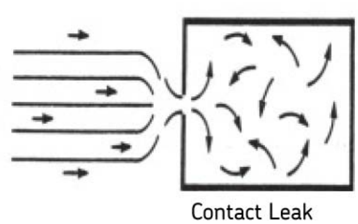

Figure 6.

A leak can be in a pressurized system or in a vacuum system. In both instances, the ultrasound is produced in the manner described above. The only difference between the two is that a vacuum leak usually generates less ultrasonic amplitude than a pressure leak of the same flow rate. The reason for this is the turbulence produced by a vacuum leak is occurring within the vacuum chamber, while the turbulence of a pressure leak is generated in the atmosphere (Figure 6).

What type of gas leak is detected ultrasonically? Generally any gas, including air, produces a turbulence when it escapes through a restricted orifice. Unlike gas specific sensors, the Inspector 400 is sound specific. A gas specific sensor is limited to the particular gas it was designed to sense (for example, helium). The Inspector 400 can sense any type of gas leak since it detects the ultrasound produced by the turbulence of a leak.

Because of its versatility, the Inspector 400 may be utilized in a wide variety of leak detection. Pneumatic systems may be checked, pressurized cables, such as those utilized by telephone companies, may be tested. Air brake systems on railroad cars, trucks, and buses may be checked. Tanks, pipes, housings, casings and tubes are easily tested for leakage by pressurizing them. Vacuum systems, turbine exhausts, vacuum chambers, material handling systems, condensers, oxygen systems can all easily be tested for leakage by listening for the turbulence of the leak.

How to locate leaks:

- Use the Scanning Module.
- Start with the sensitivity selection at 8 (Maximum).
- Begin to scan by pointing the module towards the test area. Adjust sensitivity from “gross” to the “fine” - more and more subtle adjustments will be made as the leak is approached.
- If there is too much ultrasound in the area, reduce the sensitivity setting and continue to scan.
- If it is difficult to isolate the leak due to competing ultrasound, place the Rubber Focusing Probe over the scanning module and proceed to scan the test area.
- Listen for a “rushing” sound while observing the meter.
- Follow the sound to the loudest point. The meter will show a higher reading as the leak is approached.
- In order to focus on the leak, keep reducing the sensitivity setting and move the instrument closer to the suspected leak site until you are able to confirm a leak.

Figure 7. Detecting a Leak.

To confirm a leak:

- Position the Scanning Module, or the rubber focusing probe (if it is on the scanning module) close to the suspect leak site and move it, slightly back and forth, in all directions. If the leak is at this location, the sound increases and decreases in intensity as you sweep over it. In some instances, it is useful to position the rubber focusing probe directly over the suspect leak site and push down to “seal” it from surrounding sounds. If it is the leak, the rushing sound continues; if it is not the leak site, the sound drops off.

Overcoming Difficulties

Competing Ultrasounds

If competing ultrasounds make it difficult to isolate a leak, there are two approaches to be taken:

- Manipulate the environment. This procedure is fairly straight forward. When possible, turn off the equipment that is producing the competing ultrasound, or isolate the area by closing a door or window.
- Manipulate the instrument and use shielding techniques. If environmental manipulation is not possible, try to get as close to the test site as possible, and manipulate the instrument so that it is pointing away from the competing ultrasound. Isolate the leak area by reducing the sensitivity of the unit and by pushing the tip of the rubber focusing probe up to the test area, checking a small section at a time.

Shielding Techniques

Since ultrasound is a high frequency, short wave signal, it can usually be blocked or "shielded."

> ➢ When using any method, be sure to follow your plant's or company's safety guidelines. Some common techniques are:

Figure 7.

- Body: place your body between the test area and the competing sounds to act as a barrier.
- Gloved Hand: (use caution) using a gloved hand, wrap the hand around the rubber focusing probe tip so the index finger and thumb are close to the very end, and place the rest of the hand on the test site so that there is a complete

barrier of the hand between the test area and the background noise. Move the hand and instrument together over the various test zones.

- Barrier: When covering a large area, it is sometimes helpful to use some reflective material, such as a welder's curtain or a drop cloth, to act as a barrier. Place the material so that it acts as a "wall" between the test area and the competing sounds. Sometimes the barrier is draped from ceiling to floor, at other times it is hung over railings.

Low Level Leaks

In ultrasonic inspection of leakage, the amplitude of the sound often depends upon the amount of turbulence generated at the leak site. The greater the turbulence, the louder the signal; the less the turbulence, the lower the intensity of the signal. When a leak rate is so low that it produces little if any turbulence that is detectable, it is considered "below threshold." If a leak appears to be of this nature:

- Build up the pressure (if possible) to create greater turbulence.
- Utilize Liquid Leak Amplifier.

This patented method incorporates a CMAC 8600-5 product called Liquid Leak Amplifier (LLA). LLA is a uniquely formulated liquid sub stance with special chemical properties. Used as an ultra-sonic bubble test, a small amount of LLA is poured over a suspected leak site. It produces a thin film through which the escaping gas passes. When it comes in contact with a low flow of gas, it quickly forms a large number of small “soda-like” bubbles that burst as soon as they form. This bursting effect produces an ultrasonic shock wave that is heard as a crackling sound in the headphones. In many instances the bubbles are not seen but heard. This method is capable of obtaining successful leak checks in systems with leaks as low as 1x10-6 ml / sec.

- The LLA's low surface tension is the reason small bubbles form. This can be negatively changed by contamination of the leak site with another leak fluid which can block LLA or cause large bubbles to form. If contaminated, clean the leak site with water, solvent, or alcohol (check with plant regulations before selecting a decontaminating cleaning agent).

Electric Arc, Corona, Tracking Detection

There are three basic electrical problems that are detected with the Inspector 400:

Arcing: An arc occurs when electricity flows through space. Lightning is a good example.

Corona: When voltage on an electrical conductor, such as an antenna or high voltage transmission line exceeds the threshold value, the air around it begins to ionize to form a blue or purple glow.

Tracking: Often referred to as “baby arcing,” follows the path of damaged insulation.

Although the Inspector 400 can be used in low, medium and high voltage systems, most applications tend to be in medium and high voltage systems.

When electricity escapes in high voltage lines or when it “jumps” across a gap in an electrical connection, it disturbs the air molecules around it and generates ultrasound. Most often this sound is perceived as a crackling or “frying” sound, in other situations it is heard as a buzzing sound.

Typical applications include: insulators, cable, switchgear, buss bars, relays, contactors, and junction boxes. In substations, components such as insulators, transformers, and bushings may be tested.

Ultrasonic testing is often used at voltages exceeding 2,000 volts, especially in enclosed switchgear. Since ultrasound emissions can be detected by scanning around door seams and air vents, it is possible to detect serious faults such as arcing, tracking, and corona without taking the switchgear off line to perform an infrared scan. However, it is recommended that both tests be used with enclosed switchgear.

Important! When testing electrical equipment, follow your plant or company's safety procedures. When in doubt, ask your supervisor. Never touch live electrical apparatus with the Inspector 400.

The method for detecting electric arc and corona leakage is similar to the procedure outlined in leak detection. Instead of listening for a rushing sound, a user listens for a crackling or buzzing sound. In some instances, as in trying to locate the source of radio / TV interference or in substations, the general area of disturbance may be located with a gross detector such as a transistor radio or a wide-band interference locator. Once the general area has been located, the scanning module of the Inspector 400 is utilized with a general scan of the area. The sensitivity is reduced if the signal is too strong to follow. When this occurs, reduce the sensitivity to get a midline reading on the meter and continue following the sound until the loudest point is located.

Determining whether a problem exists or not is relatively simple. By comparing sound quality and sound levels among similar equipment, the problem sound tends to be quite different.

On lower voltage systems, a quick scan of bus bars often picks up a loose connection. Checking junction boxes can reveal arcing. As with leak detection, the closer one gets to the emission site, the louder the signal.

Figure 8. Test switchgear, transformers, etc., for arcing, tracking, and corona.

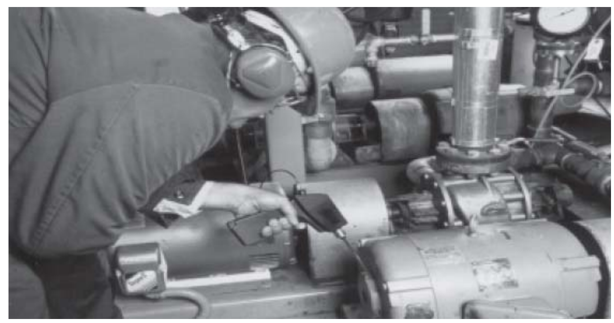

Figure 9.

General Mechanical Inspection / Detection

Ultrasonic inspection and monitoring of the mechanical condition of a machine is another method for detecting incipient (the onset of) bearing failure. The ultrasonic warning generally appears prior to a rise in temperature or an increase in low frequency vibration levels.

Ultrasonic inspection of bearings is a useful tool in recognizing:

- The beginning of fatigue failure.
- Brinelling of bearing surfaces.
- Flooding of or lack of lubricant.

In ball bearings, as the metal in the raceway, roller or ball bearing begins to fatigue, a subtle deformation begins to occur. This deforming of the metal produces an increase in the emission of ultrasonic sound waves.

Changes in amplitude from 12 to 50 times the original reading is indication of incipient bearing failure. When a reading exceeds any previous reading by 12 db, it can be assumed that the bearing has entered the beginning of the failure mode.

This information was originally discovered through experimentation performed by NASA on ball bearings. In tests performed while monitoring bearings at frequencies ranging from 24 through 50 kHz, they found that the changes in amplitude indicate incipient bearing failure before any other indicators including heat and vibration changes. An ultrasonic system based on detection and analysis of modulations of bearing resonance frequencies can provide subtle detection capability similar to the proven SKF method of "Acceleration Enveloping;" whereas conventional vibration monitoring methods are incapable of detecting very slight faults. As a ball passes over a pit or fault in the race surface, it produces an impact. A structural resonance of one of the bearing components vibrates or “rings” by this repetitive impact. The sound produced is observed as an increase in amplitude in the monitored ultrasonic frequencies of the bearing.

Brinelling of bearing surfaces produces a similar increase in amplitude due to the flattening process as the balls get out of round. These flat spots also produce a repetitive ringing that is detected as an increase in amplitude of monitored frequencies.

The ultrasonic frequencies detected by the Inspector 400 are reproduced as audible sounds. This “heterodyned” signal can greatly assist a user in determining bearing problems. When listening, it is recommended that a user become familiar with the sounds of a good bearing. A good bearing is heard as a rushing or hissing noise. Crackling or rough sounds indicate a bearing in the failure stage. In certain cases, a damaged ball can be heard as a clicking sound whereas a high intensity, uniform rough sound may indicate a damaged race or uniform ball damage. Loud rushing sounds similar to the rushing sound of a good bearing, only slightly rougher, can indicate lack of lubrication. Short duration increases in the sound level with “rough” or “scratchy” components indicate a rolling element hitting a “flat” spot and sliding on the bearing surfaces rather than rotating. If this condition is detected, more frequent examinations should be scheduled.

Detecting Bearing Failure

Comparative Testing - The comparative method involves testing two or more similar bearings and "comparing" potential differences.

To perform a Comparative Test:

- Use contact (stethoscope) module.
- Select a "test spot" on the bearing housing. Touch the spot with the contact module.In ultrasonic sensing, the more mediums or material's ultrasound has to travel through, the less accurate the reading. Therefore, be sure the contact probe is actually touching the bearing housing. If this is difficult, touch a grease fitting or touch as close to the bearing as possible.
- Approach the bearings at the same angle, touching the same area on the bearing housing.
- Reduce sensitivity (if unsure of this procedure, refer to Sensitivity Selection Dial).
- Listen to bearing sound through headphones to hear the "quality" of the signal for proper interpretation.
- Select same type bearings under similar load conditions and same rotational speed.
- Compare differences of meter reading and sound quality.

It is important to consider two elements of potential failure. One is lack of lubrication, the other is over lubrication.

Normal bearing loads cause elastic deformation of the elements in the contact area, which give a smooth elliptical stress distribution. But bearing surfaces are not perfectly smooth. For this reason, the actual stress distribution in the contact area is affected by a random surface roughness. In the presence of a lubricant film on a bearing surface, there is a dampening effect on the stress distribution and the acoustic energy produced is low. Should lubrication be reduced to a point where the stress distribution is no longer present, the normal rough spots make contact with the race surfaces and increase the acoustic energy. These normal microscopic disuniformities begin to produce wear and the possibilities of small fissures may develop, which contributes to the “Pre-Failure” condition. Therefore, aside from normal wear, the fatigue or service life of a bearing is strongly influenced by the relative film thickness provided by an appropriate lubricant.

Slow Speed Bearings

Monitoring slow speed bearings is possible with the Inspector 400. Due to the sensitivity range, it is quite possible to listen to the acoustic quality of bearings. In extremely slow bearings (less than 25 RPM), it is often necessary to disregard the meter and listen to the sound of the bearing. In these extreme situations, the bearings are usually large (1 to 2 in or more) and greased with high viscosity lubricant. Most often no sound is heard as the grease absorbs most of the acoustic energy. If a sound is heard, usually a crackling sound, there is some indication of deformity.

General Mechanical Trouble Shooting

As equipment begins to fail due to component wear, breakage, or misalignment, sonic, and more importantly, ultrasonic shifts occur. The accompanying sound pattern changes can save time and guess work in diagnosing problems if they are adequately monitored. Therefore, an ultrasonic history of key components can prevent unplanned down time. And just as important, if equipment should begin to fail in the field, the Inspector 400 can be extremely useful in trouble shooting problems.

To trouble shoot:

- Use the contact (stethoscope) module.
- Touch test area(s). Listen through headphones and observe the meter.
- Adjust sensitivity until mechanical operation of the equipment is heard clearly.
- Probe equipment by touching various suspect areas.
- To focus on problem sounds; while probing, reduce sensitivity gradually to assist in locating the problem sound at its loudest point. (This procedure is similar to the method outlined in Leak Location; for example, follow the sound to its loudest point.)

Figure 10.

Locating Faulty Steam Traps

An ultrasonic test of steam traps is a positive test. The main advantage to ultrasonic testing is that it isolates the area being tested by eliminating confusing background noises. A user can quickly adjust to recognizing differences among various steam traps, of which there are three basic types: mechanical, thermostatic, and thermodynamic.

When testing steam traps ultrasonically:

- Determine what type of trap is on the line. Be familiar with the operation of the trap. Is it intermittent or continuous drain?
- Try to check whether the trap is in operation (is it hot or cold? Put your hand near, but do not touch the trap, or better yet, use an SKF non-contact infrared thermometer).

- Use the contact (stethoscope) module.
- Try to touch the contact probe towards the discharge side of the trap. Press the trigger and listen.
- Listen for the intermittent or continuous flow operation of the trap. Intermit tent traps are usually the inverted bucket, thermodynamic (disc), and thermostatic (under light loads). Continuous flow: include the float, float, and thermostatic and (usually) thermostatic traps. While testing intermittent traps, listen long enough to gauge the true cycle. In some cases, this may be longer than 30 seconds. Bear in mind that the greater the load that comes to it, the longer period of time it will stay open.

When checking a trap ultrasonically, a continuous rushing sound is often the key indicator of live steam passing through. There are subtleties for each type of trap that can be noted.

Use the sensitivity levels of the Sensitivity Selection Dial to assist your test. If a low pressure system is to be checked, adjust the sensitivity toward 8; if a high pressure system (above 100 psi) is to be checked, reduce the sensitivity level. (Some experimentation may be necessary to arrive at the most desirable level to be tested.) Check upstream and reduce the sensitivity so that the meter reads about 50% or lower, then touch the trap body downstream and compare readings.

General Steam / Condensate / Flash Steam Confirmation

In instances where it may be difficult to determine the sound of steam, flash steam or condensate:

- Touch at the immediate downstream side of the trap and reduce the sensitivity to get a midline reading on the meter (about 50%).
- Move 15.2 to 30.5 cm (6 to 12 in) downstream and listen. Flashing steam will show a large drop off in intensity while leaking steam will show little drop off in intensity.

Inverted Bucket Traps normally fail in the open position because the trap loses its prime. This condition means a complete blow through, not a partial loss. The trap will no longer operate intermittently. Aside from a continuous rushing sound, another clue for steam blow through is the sound of the bucket clanging against the side of the trap.

A Float and Thermostatic trap normally fails in the “closed” position. A pinhole leak produced in the ball float causes the float to be weighted down, or water hammer collapses the ball float. Since the trap is totally closed, no sound is heard. In addition, check the thermostatic element in the float and thermostatic trap. If the trap is operating correctly, this element is usually quiet; if a rushing sound is heard, this indicates either steam or gas is blowing through the air vent. This indicates that the vent failed in the open position and is wasting energy.

Thermodynamic (DISC) traps work on the difference in dynamic reponse to velocity change in the flow of compressible and incompressible fluids. As steam enters, static pressure above the disc forces the disc against the valve seat. The static pressure over a large area overcomes the high inlet pressure of the steam. As the steam starts to condense, the pressure against the disc lessens and the trap cycles. A good disc trap should cycle (hold-discharge-hold) 4 to 10 times per minute. When it fails, it usually fails in the open position, allowing continuous blow through of steam.

Thermostatic Traps (bellows and bimetallic) operate on a difference in temperature between condensate and steam. They build up condensate so the temperature of condensate drops to a certain level below saturation temperature in order for the trap to open. By backing up condensate, the trap tends to modulate open or closed depending on load.

In a bellows trap, should the bellows become compressed by water hammer, malfunction occurs. The occurrence of a leak prevents the balanced pressure action of these traps. When either condition occurs, the trap fails in its natural position either opened or closed. If the trap fails closed, condensate backs up and no sound is heard. If the trap fails open, a continuous rushing of live steam is heard.

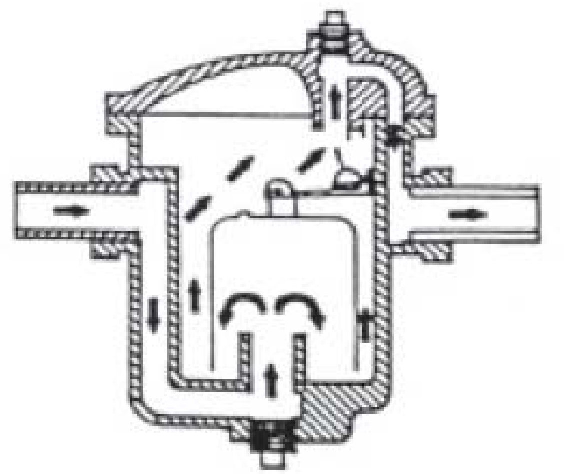

Figure 11. Normal Steam Trap Operation (Inverted Bucket).

With bimetallic traps, as the bimetallic plates set due to heat they sense and the cooling effect on the plates, they may not set properly, which prevents the plates from closing completely, allowing steam to pass through. This is heard as a constant rushing sound.

Locating Faulty Valves

Figure 12.

Utilizing the contact (stethoscope) module in the Inspector 400, valves can be easily monitored to determine if they are operating properly. As a liquid or gas flows through a pipe, there is little or no turbulence generated except at bends or obstacles. In the case of a leaking valve, the escaping liquid or gas moves from a high to a low pressure area, creating turbulence on the low pressure or “down stream” side. This produces white noise. The ultrasonic component of this white noise is much stronger than the audible component. If a valve is leaking internally, the ultrasonic emissions generated at the orifice site are heard and noted on the meter. The sounds of a leaking valve seat varies depending upon the density of the liquid or gas. In some instances it is heard as a subtle crackling sound, at other times as a loud rushing sound. Sound quality depends on fluid viscosity and internal pipe pressure differentials. As an example, water flowing under low to mid pressures may be easily recognized as water. However, water under high pressure rushing through a partially open valve may sound very much like steam. To discriminate, reduce the sensitivity, touch a steam line and listen to the sound quality, then touch a water line. Once you have become familiar with the sound differences, continue your inspection.

A properly seated valve generates no sound. In some high pressure situations, the ultrasound generated within the system is so intense surface waves travel from other valves or parts of the system and make it difficult to diagnose valve leakage. In this case it is still possible to diagnose valve blow through by comparing sonic intensity differences by reducing the sensitivity and touching just upstream of the valve, at the valve seat, and just downstream of the valve.

Valve Check Procedure

- Use the stethoscope module.
- Touch downstream side of valve and listen through headset.
- When necessary, if there is too much sound, reduce sensitivity.
- For comparative readings, usually in high pressure systems:
- Touch upstream side and reduce sensitivity to minimize any sound (usually bring the meter to a mid-line 50 % reading).
- Touch valve seat and/or downstream side.
- Compare sonic differentials. If the valve is leaking, the sound level on the seat or

downstream side will be equal to or louder than the upstream side.

Confirming Valve Leakage in Noisy Pipe Systems

Occasionally in high pressure systems, stray signals occur from valves that are close by or from pipes (or conduits) feeding into a common pipe that is near the down stream side of a valve. This flow may produce false leak signals. To determine if the loud signal on the down stream side is coming from a valve leak or from some other source:

- Move close to the suspected source (for example, the conduit or the other valve).
- Touch at the up stream side of the suspected source.
- Reduce sensitivity until the meter displays a midline (50 %) reading.
- Touch at short intervals (such as every 15 to 30.5 cm (6 to 12 in)) and note the meter changes.
- If the sound level decreases as you move towards the test valve, it indicates the valve is not leaking.
- If the sound level increases as you approach the test valve, it is an indication of a leak in the valve.