FYI - Small Systems

Small Systems Committee
INDIANA SECTION AWWA

FYI - Small Systems **October, 2012**

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FYI

With this edition of FYI-Small Systems, we are featuring a number of updates from our friends at IDEM, and also discussing Motor Failures and Financial Planning for your utility.

As winter weather is just around the corner, we have included the ever-popular "Winterizing Tips". This constantly evolving checklist is a great tool as you prepare your system for the cold, ice, and snow. If you have any tips to add to the list, please share them with us.

The **InAWWA 2013 Annual Conference** is scheduled for **February 11 – 14** and will be held at the Marriott in downtown Indianapolis. The Small Systems Committee will once again be sharing booth space with the Young Professionals Committee and the Water For People Committee. Please stop by to see us, or if you wish to meet with any of the Small Systems Committee members during the Conference, just give us a call.

WHAT'S UP WHAT'S NEW - IDEM

As they say, the only constant is change. Once again the Field Inspection Section is experiencing personnel changes. Bill Morgan of the Northern Regional Office, South Bend, retired recently. Adrianne Mishler has transferred into that position. Adrianne was with our Office of Air. She is in training now. Larey Conquergood passed away in July. Bridget Murphy was promoted into that Senior Environmental Manager position leaving her field position vacant. Jeff Guinn of our Northwest Regional Office (NWRO) will transfer to Indianapolis to fill that position. Jeff's vacated position in the NWRO has been posted. We will be conducting interviews soon and hope to have that position filled in the next couple of weeks. Paul Dick will be retiring at the end of November. We will make the request to fill the position at that time. Hopefully we will be given the go ahead to fill the vacancy. Our current inspector list is in this issue. This is it for the time being.

Rick Miranda retired earlier this year. April Swift was promoted into that position. The job duties have changed somewhat. Marc Hancock will be taking over the cross connection control program. April will be working with all sections on database requirements among other things. As part of her database duties she will be helping us with the new electronic sanitary survey affectionately known as Digital Inspector or DI. We launched DI on July 2. Bridget is the Field Section project manager for DI. With DI copies of the report will not be left on site. A letter with the survey report will follow the inspection. As with any new program, there are bugs to workout. One of those bugs is that the letter portion of the program is not quite there yet. We are hoping to get this worked out soon. You will get the letters just not on the spot.

There have been some other personnel changes in other sections. The lists for all sections are included in this issue.

If you have any questions you can contact me at lmelvin@idem.in.gov or at 317/234-7418.

REMINDER - IDEM

A reminder to systems, developers, consultants and engineers that a General Permit aka Notice of Intent (NOI: 327 IAC 83.5) is *only* used for water main extensions and there are some eligibility requirements. But the main thing to remember is that there is *never* a waiver on a NOI. The NOI is for simple main extensions using no new alternative technical standards and construction cannot begin until 30 days after IDEM receives the NOI form. If construction begins prior to the 30 days, a system risks a Construction Without a Permit violation. All NOIs must be submitted to IDEM via certified mail so they will know when IDEM received it. If a system is already at 90% capacity, the NOI may be rejected. If the form is incomplete or inaccurate, it may be rejected. Systems will be notified if a NOI has been rejected for any reason. Resubmittal of a NOI or regular permit application may be required before construction can begin. Any more questions, please contact Sherri Winters, 317-232-8624 or **swinters@idem.in.gov**.

FYI FROM THE SECTION CHAIR

Hello my friends, it is an honor to serve you as Section Chair this year. I have enjoyed your hospitality as I have traveled around the State of Indiana participating in the District Meetings.

One of the things that I learned as I traveled all over the beautiful State of Indiana was that it did not matter which District I was in, the challenges the operators faced were much the same. Whether that challenge is a disgruntled customer, a meter reading issue, a water quality issue or a broken water main.

In September, the John N. Hurty Awards were presented to individuals that had served 25 years or more in the Water Industry. There were water industry professionals from all across the State that came forth to receive their awards. These men and women have served Indiana utilities for 25, 30, 35, 40, 45, 50 and 55 years. **They** are the individuals that I would want to work on these challenging water issues!

This is one of the great values of the American Water Works Association. Our organization brings water professionals together from all over the State to share experiences and help each other to overcome challenges in our respective water systems. When you add in the education, the standards, and the manuals that help us do our jobs you realize a better appreciation of the worth of our memberships in the Indiana Section of the American Water Works Association.

Please step up and get involved in your District and your Section to promote your community, utility and yourselves. This involvement will take your professional career to a new level and you will be rewarded on a level that is commensurate to the level of service you provide. The extras that we do for our customers are often worth more than all the rest that we have to do.

Please visit www.inawwa.org to see the upcoming Small System and InWARN workshops throughout Indiana.

I am looking forward to seeing you at the 2013 Annual Meeting scheduled for February 11 - 14 at the Marriott in downtown Indianapolis and at the Water For People events throughout the year.

Duane Gilles
InAWWA Section Chair

LAY A FOUNDATION FOR YOUR UTILITY'S FUTURE WITH FINANCIAL PLANNING

What do you do when your refrigerator stops working and needs replacing? Or when your car breaks down and needs a new alternator? These are usually unexpected events, and this is where a rainy-day fund comes in handy.

In the same way, businesses and organizations - and your utility - need funds for unexpected expenses. Building up reserve funds is one part of planning for the financial future of your system. Financial planning is one of the most important responsibilities of managers and members of the board or governing body of a utility.

A financial plan is basically a two-part process composed of:

- forecasting the utility's future financial needs (operating and capital needs)
- determining how those future financi8al needs will be met

Capital-improvements planning

A capital-improvements plan (called a CIP for short or sometimes called a long-range plan) is written document that specifies:

- what facility improvements will be needed in the future
- when the improvements will be needed and when they will be undertaken
- how much the improvements will cost
- what financing options are available for the improvements

A CIP should cover at least a ten-year period of time into the future. Having one will help your utility's board and management make informed decisions about rate setting, future debt-service requirements, and future revenue requirements.

Reserve Accounts

The purpose of reserve accounts is to hold funds that are dedicated for specific uses. These accounts should be built up over time with revenues from the operator of your facility. For specific reserve accounts are recommended for water and wastewater utilities:

1. **Debt-service reserve:** A debt-service reserve is usually required by a lender or bond-covenant agreements. The debt-service reserve is for making regular debt-service payments should other funds for making debt-service payments *not* be available.
2. **Emergency reserve:** An emergency reserve fund is for unforeseen and unplanned emergency repairs that may occur during the year, such as major line breaks, pump breakdowns, etc.
3. **Planned equipment repair/replacement reserve:** this reserve fund is for the planned repair, rehabilitation, or replacement of equipment. In particular, this reserve is meant for the replacement of those items that have a useful life that is significantly shorter than the system as a whole. (This reserve may also be called a short-lived assets reserve.)
4. **(Major) Capital-improvements reserve:** A capital-improvements reserve is the accumulation of funds that will be devoted to pay for part of the cost of large, future capital-improvement projects that might be needed for the upgrade of existing facilities or construction of new facilities. Most of the cost for major capital-improvement projects will be paid with the outside sources of financing. (For small water or wastewater systems - those with a small customer base and lower annual revenues - it might not be possible to fund a major capital-improvements reserve at all without increasing rates above an affordable level.)

Planned repair and replacement

A financial plan for equipment replacement, repair and rehabilitation is an example of how your utility can use its own financial resources to fund minor capital improvements.

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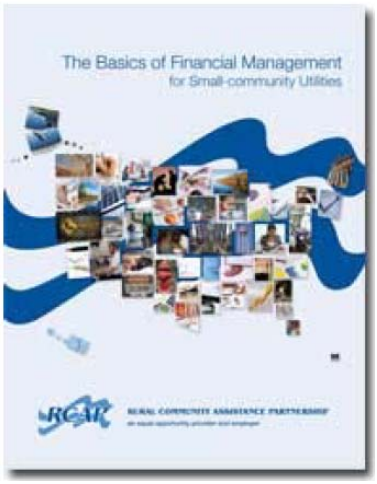
LAY A FOUNDATION FOR YOUR UTILITY'S FUTURE WITH FINANCIAL PLANNING (CONTINUED)

(Continued from page 3)

Through a planning process sometimes referred to as "asset management", decision-makers can identify, prioritize and schedule the repair, replacement or rehabilitation of critical components in your system. The cost of completing these types of improvements would be funded through an equipment-repair/replacement reserve. An equipment repair and replacement program is particularly important fo9r replacing critical assets with a useful and serviceable life that is much shorter than the entire system.



For more explanations of these parts of financial planning and how to carry them out, get RCAP's The Basics of Financial Management for Small-Community Utilities. This article is taken from chapter 2 of the guide. This 38-page booklet is written in plain, everyday English and is meant for both new and experienced managers and leaders in small-community utilities to help you get your financial affairs in order. Other chapters provide sample financial-management policies and explanations for reading and interpreting standard financial statements (especially helpful for people who do work in book keeping or accounting).

Also, the Environmental Protection Agency has numerous publications, tools, and resources on asset management. For more information, visit the EPA Small Systems website.

WINTERIZING TIPS FOR WATER UTILITIES

Before long the cold winter air will be hitting us in the face. The question is: Are you prepared for the bitter cold weather that will come and can cause you so many problems? The purpose of this article is to get you brainstorming on what areas you might have in your water system or community that could be potential problems or risk due to the cold weather.

As the weather turns colder and the leaves start turning their brilliant fall colors, and especially before the snow flies, you need to prepare your system.

Here are a few areas that should be checked in your community and water utility, we call it our winterizing checklist.

- ☐ Start working on your winterizing checklist before the cold weather sets in. Set a deadline for when this checklist should be completed.
- ☐ Be sure your employees have appropriate cold weather gear if they will be working out in cold weather conditions.
- ☐ Check for fire hydrants that do not drain properly. You may have notes on these from your flushing program; if not, it may take awhile to check all of your fire hydrants so start early. Once you have identified the problem hydrants, you need to pump them down at least 3' below ground level. You will want to check these problem hydrants a couple of days after pumping them down to see if water is leaking by the main seat and filling the barrel of the fire hydrant back up.
- ☐ Check any areas in which you may use heat tape. You will want to make sure that the heat tapes are working properly. If the heat tape is 3-4 years old you may want to strongly consider replacing that heat tape.
- ☐ Does your community have park restrooms or water fountains that need drained or winterized?
- ☐ Your water tower is one of your biggest assets and should be a concern during the winter months. You can vary the water level in your tank on a daily basis to keep from having major freezing problems. If your tank overflows on a regu-

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WINTERIZING TIPS FOR WATER UTILITIES (CONTINUED)

(Continued from page 4)

lar basis, you need to correct the problem before the hard winter gets here. (A water tank can collapse with excess ice build-up.)

- ☐ Do you have an auxiliary heat source available in your well house in case power would go off for more than a couple hours?
- ☐ If you have any machinery that stays out in the weather or is in an unheated garage, be sure to check antifreeze strength, it should be down to at least –25 degrees F.
- ☐ Winterize mowers and equipment that will sit all winter. Gas stabilizer in October makes things so much easier in April.
- ☐ Check insulation and weather-stripping on all facilities in order to reduce the cost of heating those spaces.
- ☐ Inspect your facilities for small openings where mice and other small animals could find their way into the facility. In addition to the health concerns from their droppings, mice can cause a lot of damage.
- ☐ Check pits for leaks, insulators, and conduct an overall inspection.

While conducting winterizing inspections, this would be a good time to check security needs for each site.

- ☐ Secure access ways with chains and/or locks
- ☐ Clear fences and make sure they are properly maintained
- ☐ Close and lock gates
- ☐ Make provisions for proper snow removal if access is needed during the winter
- ☐ Make sure any security or freeze alarms are all operational
- ☐ Remind your seasonal customers of some winterizing tips for their home when they call in for their seasonal disconnect. (Draining of water line, *if they don't have hot water heat of course*, turn back thermostat on furnace and hot water heater.)
- ☐ Find out an approximate return time of your seasonal customer to be verified with a phone call. Just in case of a problem you should see if they will give you a phone number so they can be contacted in case of an emergency.

WELLS and PUMPING EQUIPMENT:

- ☐ Check your pump houses to make sure there is an adequate heater with a thermostat to maintain enough heat in the building so the discharging piping and any sensing lines in the building will not freeze.
- ☐ If there is a vertical turbine pump in the pump house, there will be a small amount of water trickling out of the stuffing box, which is normal. You must make sure the water has proper drainage away from the pump house.
- ☐ On a submersible pump, you want to maintain proper heat in the building so when the pump is off, it will not freeze.
- ☐ For wells and pumps on pitless adapters, you must ensure the wells are covered properly and protected against snow, hail, and ice getting in them, yet allowing them to be vented to atmosphere.
- ☐ If there is a pit for booster pumps or check valves, ensure the top is sealed as with the pitless adapters.
- ☐ To avoid accidents with snowmobiles and snow plows, make sure that if you have test wells or wells with pitless adapters, they are very visibly marked so they may be located easily in deep or drifting snow.
- ☐ When spring arrives, do not forget to shut off your heaters to prevent overheating and save fuel.

STORAGE TANKS:

- ☐ The leading causes of tank freeze ups in Indiana are a lack of circulation and operator awareness.
- ☐ Ice formation occurs when water sits in a tank long enough to have heat transfer through the tank wall lower the temperature to freezing. Smaller tanks are more susceptible to freezing as their surface area to volume ratio is lower. A 100,000 gallon elevated tank has approximately 30 gallons of water stored for every square foot of surface area, while a

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WINTERIZING TIPS FOR WATER UTILITIES (CONTINUED)

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1,000,000 gallon elevated tank has approximately 68 gallons per square foot. The more steel surface area there is per gallon, the faster heat will transfer. The same relationship applies to pipes. A 4-inch diameter pipe has 0.62 gal/sq.ft., while a 24-inch diameter has 3.75 gal/sq.ft. That is why a small pipe without circulation will freeze solid much faster than a large one. There is much less water to freeze and the heat transfer rate is much higher.

- ☐ Groundwater systems have a major advantage as the incoming water is around 46-48 degrees F and adds heat to the tank every time it is filled. As a rule of thumb, if the volume of a tank can be turned over at least every two days during the winter, freezing should not be a concern for a groundwater system. Surface water supplies have a more difficult time as for several months they are pumping water that is 33-34 degrees F and will freeze quickly if circulation is not adequate.
- ☐ Make sure any water towers or ground storage tanks have their sensing lines properly insulated or heat taped to prevent false readings and to allow the water to be turned, keeping it fresh.
- ☐ Adjust pump cycles as needed to ensure that water circulates frequently each day. Demands in the winter are lower, so the pump operating levels may need adjustment.
- ☐ Consider changing filling operations to lower demand times. This ensures most of the new warmer water enters the tank first instead of being used directly to meet system demands.
- ☐ Consider reducing overall tank volumes. As long as the fire flow minimum storage volume is maintained, the tank volume can usually be reduced without a noticeable effect on system pressures.
- ☐ Insulate fill pipes and use heat tape where practical. Without adequate circulation, the fill pipe will freeze before the tank due to its high heat transfer rate.
- ☐ Install temperature alarms on the fill pipe and riser. These can be tied into your control or SCADA system to warn of impending freezing.
- ☐ Use warmer water sources where possible. If you have dual sources, try to use ground water instead of surface water during the winter.
- ☐ If altitude values are used on multiple tank systems, they should be serviced routinely to ensure proper operation.
- ☐ For worst cases, consider installing a recirculation system. These are commonly found on industrial tanks that are only used for fire protection. A new municipal tank built for future service demands could also temporarily have this problem, as can school water supply systems. Recirculation systems are effective, but require close monitoring to ensure they work properly.
- ☐ Most importantly, be sure that your control system provides a continuous reading of tank levels. The old fashioned circular chart recorders work fine, as do the more modern computerized telemetry. Paying close attention to this data will help to identify circulation concerns.

BACKFLOW:

- ☐ The best way to prevent freezing on an irrigation system is to have the assembly removed for the winter months then re-install and test the assembly in the Spring when it is warmer. Another option is to turn off the shut-off valve and drain the assembly by opening the test cocks.
- ☐ Whether your assembly stays in use for the winter, be sure the backflow cover fits securely to the ground to prevent air infiltration. Check the cover for any crackcs, holes, splits, etc.
- ☐ Cover the assembly with insulation inside the enclosure.
- ☐ If electricity is available, install a damp rated heat tape around the assembly and piping inside the cover.

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WINTERIZING TIPS FOR WATER UTILITIES (CONTINUED)

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EMERGENCY PREPARATION:

- ☐ Take out your emergency management plan and review.
- ☐ Update emergency contact phone numbers.
- ☐ Place emergency management plan with emergency contact phone numbers in a prominent location in y our office. Label it so that if you are not there, others who may be called on to fill in for you will be able to find it and use it.
- ☐ Get permission from your board, town manager, or mayor to identify and cross-train two or three individuals so that they can operate the system safely during an emergency. Then get them cross-trained. TIP: Look for suitable retirees in your community to fill this need if you do not have access to other personnel within your organization.
- ☐ Write down your critical operating procedures and maybe even put labels on some of the equipment and controls. Have the people who you are cross-training help you write the procedures and identify what needs to be labeled.
- ☐ Make a list of your current chemical suppliers, including phone numbers, and a list of the specific chemicals you purchase on a regular basis.
- ☐ Assemble a set of spare keys and put them in a location where the folks you cross-trained can gain access to them.

EMERGENCY STOCK ITEMS:

- ☐ Repair Clamps
- ☐ MJ Sleeves
- ☐ Compression Fittings
- ☐ Roll Plastic
- ☐ Lids and Rings
- ☐ Saddles(3/4 and 1”)
- ☐ Valve Boxes (tops and bottoms)
- ☐ Back-Up Generators (pull behinds, portables, etc.)
- ☐ Drinking water safe hose and fittings for interconnecting houses, if needed, due to frozen pipes.
- ☐ Pipe thawing equipment – own, rent, or borrow
- ☐ Meter Pit Insulators

Have a safe, enjoyable winter! Remember, Indiana has quick and unexpected weather changes, so start your cold weather preparedness now!

MARK YOUR CALENDARS (CONTINUED)

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March 11, 2013 – Wastewater Treatment Plant Operator Certification Examination Application submission must be postmarked by this date. The application can be downloaded from IDEM's website at http://www.in.gov/idem/5088.htm. The Wastewater Treatment Plant Operator Certification Examination will be given April 25, 2013. Contact: Rebecca McMonigle, IDEM, 317-232-8791, rmcmonig@idem.in.gov.

March 13-14, 2013 – Alliance of Indiana Rural Water – Spring Conference – Bloomington Convention Center; Bloomington, Indiana. Contact: LeighAnn Cross or Laura Vidal at 888-937-4992 or visit the Alliance website at www.inh2o.org

April 15 – 17, 2013 – Indiana Rural Water Association – 2013 Spring Conference – Clarion Conference Center (formerly Holiday Inn); Columbus, Indiana. Contact: Odetta Cadwell at 317-402-7349; MaryJane Miller at 866-895-4792 (toll free); or visit the IRWA website at www.indianaruralwater.org

April 15, 2013 – Indiana Rural Water Association – 2013 Annual Golf Outing – Otter Creek Golf Course; Columbus, Indiana. Contact: Odetta Cadwell at 317-402-7349; MaryJane Miller at 866-895-4792 (toll free); or visit the IRWA website at www.indianaruralwater.org

April 25, 2013 – Wastewater Treatment Plant Operator Certification Examination. Application submission must have been postmarked by March 11, 2013. Contact: Rebecca McMonigle, IDEM, 317-232-8791, rmcmonig@idem.in.gov.

May 16, 2013 – Alliance of Indiana Rural Water – Southern Expo – Huntingburg, Indiana. Contact: LeighAnn Cross or Laura Vidal at 888-937-4992 or visit the Alliance website at www.inh2o.org

May 23, 2013 – Alliance of Indiana Rural Water – Northern Expo – Akron, Indiana. Contact: LeighAnn Cross or Laura Vidal at 888-937-4992 or visit the Alliance website at www.inh2o.org

July 31, 2013 – Indiana Section AWWA – 2013 Annual Golf Outing – Eagle Creek Golf Course; Indianapolis, Indiana. Contact: Tim Hill at 317-896-2987 or tim.hill@peerlessmidwest.com; or visit the inAWWA website at www.inawwa.org

August 8, 2013 – IRWA/AWWA Operator Boot Camp – Miami County Fairgrounds; Peru, Indiana. Contact: Odetta Cadwell at 317-402-7349; MaryJane Miller at 866-895-4792 (toll free); or visit the IRWA website at www.indianaruralwater.org or Indiana Section AWWA website at www.inawwa.org

August 19, 2013 – Wastewater Treatment Plant Operator Certification Examination Application submission must be postmarked by this date. The application can be downloaded from IDEM's website at http://www.in.gov/idem/5088.htm. The Wastewater Treatment Plant Operator Certification Examination will be given October 3, 2013. Contact: Rebecca McMonigle, IDEM, 317-232-8791, rmcmonig@idem.in.gov.

August 20-22, 2013 – Indiana Street Commissioners Association Conference – Swan Lake Resort; Plymouth, Indiana. Contact: Raymie Eckerle at 812-482-1130 or streetdept@ci.jasper.in.us or visit ISCA's website at www.indianastreets.org.

August 21-22, 2013 – Alliance of Indiana Rural Water – Fall Conference – Star Plaza; Merrillville, Indiana. Contact: LeighAnn Cross or Laura Vidal at 888-937-4992 or visit the Alliance website at www.inh2o.org

September 19, 2013 – Alliance of Indiana Rural Water – Scholarship Golf Outing – Winding Ridge Golf Course; Lawrence, Indiana. Contact: LeighAnn Cross or Laura Vidal at 888-937-4992 or visit the Alliance website at www.inh2o.org

October 1, 2013 – Long Term 2 Enhanced Surface Water Treatment Rule Deadline – Systems serving 10,000-49,999 people – Comply with additional LT2 treatment technique requirements. Contact: Yasser Elkhatib at 317-234-7451, yelkhati2@idem.in.gov OR Stacy Jones at 317-234-7454, sjones@idem.in.gov. Other information on the LT2 Rule can be obtained from www.epa.gov/safewater/disinfection/lt2

October 1, 2013 – Stage 2 Disinfection By-Products Rule Deadline – Systems serving 10,000-49,999 people – Begin Stage 2 Compliance Monitoring. Contact: Peter Poon at 317-234-7441, ppoon@idem.in.gov OR Stacy Jones at 317-234-7454, sjones@idem.in.gov. Other information on the DBPR can be obtained from www.epa.gov/safewater/disinfection/stage2

October 1, 2013 (October 1, 2014 if Crypto monitoring is required under LT2) – Stage 2 Disinfection By-Products Rule Deadline – Systems serving fewer than 10,000 people and not connected to a system that serves 10,000 or more people – Begin Stage 2 Compliance Monitoring. Contact: Peter Poon at 317-234-7441, ppoon@idem.in.gov OR Stacy Jones at 317-234-7454, sjones@idem.in.gov. Other information on the DBPR can be obtained from www.epa.gov/safewater/disinfection/stage2

October 3, 2013 – Wastewater Treatment Plant Operator Certification Examination. Application submission must have been postmarked by August 19, 2013. Contact: Rebecca McMonigle, IDEM, 317-232-8791, rmcmonig@idem.in.gov.

October 6 - 8, 2013 – Indiana Association of Cities and Towns Annual Conference – Indianapolis, Indiana. Contact: Matt Greller at 317-237-6200 or visit the IACT's website at www.citiesandtowns.org.

December 9 – 11, 2013 – Indiana Rural Water Association – 2013 Water Institute (Fall Conference) – Holiday Inn Conference Center; Columbus, Indiana. Contact: Odetta Cadwell at 317-402-7349; MaryJane Miller at 866-895-4792 (toll free); or visit the IRWA website at www.indianaruralwater.org

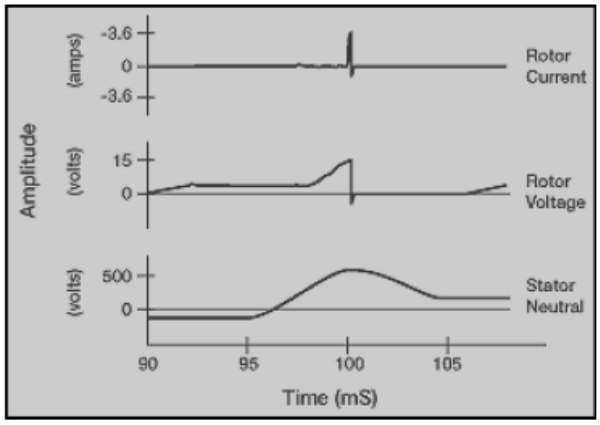
ARE BEARING CURRENTS CAUSING YOUR MOTOR FAILURES? (FA/117-03)

January 22nd, 2004

"We just lost another motor! Why are all of our motors failing?" Does this sound familiar? If you're at a loss to explain why your motors seem to experience premature failure one after another, take a step back and look at the big picture. Are all of the motors that have failed being controlled by variable frequency drives? If so, you may be experiencing the detrimental effects of shaft voltage resulting in bearing current.

What are they, why do they cause premature motor bearing failure, and how can you protect against them? To answer these questions, we first need to understand how variable frequency drives (VFDs, ADSs, or inverters) operate.

VFD Operation



Example of voltage - current relationship

VFDs regulate the speed of a motor by converting sinusoidal line AC voltage to DC voltage, then back to a pulse width modulated (PWM) AC voltage of variable frequency. The switching frequency of these pulses ranges from 1 kHz up to 20 kHz and is referred to as the "carrier frequency." The ratio of change of the $\Delta V/\Delta T$ creates a parasitic capacitance between the motor stator and the rotor, which induces a voltage on the rotor shaft. If this voltage, referred to as "common mode voltage" or "shaft voltage," builds up to a sufficient level, it can discharge to ground through the bearings. Current that finds its way to ground through the motor bearings in this manner is called "bearing current."

Let's examine how this condition develops, and what physically happens to the bearing as a result.

Bearing Fluting

Bearing Damage

It should be noted that one of the major causes of bearing current results from voltage pulse overshoot created by the fast-switching IGBT (insulated gate bipolar transistor) in the VFD. We will discuss this phenomenon in the context of this publication. Other sources of shaft voltage include non-symmetry of the motor's magnetic circuit, supply unbalances, transient conditions, and others. Any of these conditions can occur independently or simultaneously to create bearing currents.

Shaft voltage accumulates on the rotor until it exceeds the dielectric capacity of the motor bearing lubricant, then the voltage discharges in a short pulse to ground through the bearing. After discharge, the voltage again accumulates on the shaft and the cycle repeats itself.

This random and frequent discharging has an electric discharge machining (EDM) effect, causing pitting of the

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ARE BEARING CURRENTS CAUSING YOUR MOTOR FAILURES? (FA/117-03) (CONTINUED)

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bearing's rolling elements and raceways. Initially, these discharges create a "frosted" or "sandblasted" effect, and usually the first symptom of bearing current damage is the audible noise created by the rolling elements riding over these pits in the bearing race. Over time, this deterioration causes a groove pattern in the bearing race called "fluting" which is a sign that the bearing has sustained severe damage. Eventually, the deterioration will lead to complete bearing failure.

This random and frequent discharging has an electric discharge machining (EDM) effect, causing pitting of the bearing's rolling elements and raceways. Initially, these discharges create a "frosted" or "sandblasted" effect, and usually the first symptom of bearing current damage is the audible noise created by the rolling elements riding over these pits in the bearing race. Over time, this deterioration causes a groove pattern in the bearing race called "fluting" which is a sign that the bearing has sustained severe damage. Eventually, the deterioration will lead to complete bearing failure.

Problem Prediction

VFD-induced shaft voltage can exist in every VFDdriven motor application. It is not specific to the air movement industry, nor is it specific to any particular manufacturer's motors, drives or equipment. However, shaft voltage only becomes a problem when it leads to bearing current and consequential damage to the motor bearings. How can you determine if your motor bearings are at risk? The truth is that the phenomenon of shaft voltages and bearing currents is well understood and well documented, but it is also somewhat rare and unpredictable.

The National Electrical Manufacturers Association (NEMA) Publication MG 1 Section IV "Performance Standards Applying to All Machines," Part 31 "Definite-Purpose Inverter-Fed Polyphase Motors" is the industry-accepted standard for defining what we call a VFD compatible motor. This standard addresses, in part, the motor's capability with respect to temperature, torque, insulation, and operating limitations (excess current, line voltage, across-the-line starting, etc). It also addresses "shaft voltages that can result in the flow of destructive currents through motor bearings," but concludes with the following statement:

"At this time, there has been no conclusive study that has served to quantify the relationship of peak voltage from inverter operation to bearing life or failure. There is also no standard method for measuring this voltage. Because of this, the potential for problems cannot consistently be determined in advance of motor installation."

Because of the phenomenon's rarity and unpredictability, most manufacturers do not include warnings or recommendations in their literature or operation & maintenance manuals.

Contributing Factors

Amidst the unpredictable cases of bearing current damage, industry experts have identified some things that exacerbate the occurrence and promote damaging effects:

High carrier frequency

The higher the carrier frequency, the higher the rate of the current discharge pulses, or the more rapid the damage caused by EDM will occur. At higher carrier frequencies the VFD will generally run quieter, however, it becomes more destructive on the motor insulation and bearings.

Most experts recommend that the carrier frequency be adjusted as low as possible without creating unacceptable audible noise levels, and to avoid frequencies above 6 kHz altogether. Accordingly, it is generally a good idea to specify and install a VFD that has an adjustable carrier frequency by relatively small increments (i.e. by 1 kHz increments) to allow for fine-tuning to the lowest acceptable level.

Constant speed operation

Some industry experts believe that constant speed operation increases the risk of bearing current damage. Interestingly, the first well-known cases of bearing current damage were in clean room applications, in which VFDs controlled fan motors are used to maintain a constant airflow. However, there have been many cases of bearing current damage reported in air handling and other industry applications in which the equipment is not operating at a constant speed. While motor bearings operating at a constant speed are indeed more susceptible to EDM damage, motors that are in variable speed duties are certainly not immune.

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ARE BEARING CURRENTS CAUSING YOUR MOTOR FAILURES? (FA/117-03) (CONTINUED)

(Continued from page 10)

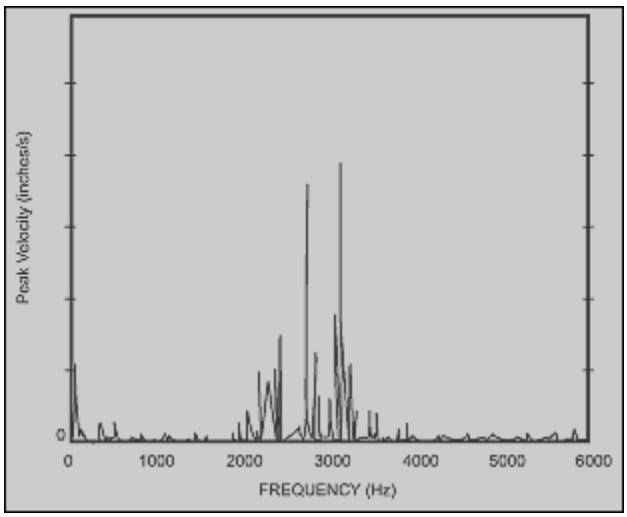
Inadequate grounding
One of the largest potential causes of motor bearing damage due to bearing currents is inadequate grounding, especially at high operating frequencies. The challenge is to provide a low impedance ground path for the voltage to flow to earth ground without passing through the motor bearings or other components. Proper grounding is especially critical on the motor frame, between the motor and the VFD, and from the VFD to earth.

Problem Identification
As stated earlier, the first symptom of bearing current damage is often the audible bearing noise. Unfortunately, by the time the bearing noise is apparent, EDM damage has already occurred and deterioration has developed to the point that complete bearing failure is probably not far behind.

Currently, there are two common non-destructive methods used in the industry to detect bearing currents and bearing current damage: vibration analysis, and shaft-to-ground voltage & current analysis. While both can be implemented to either confirm or deny bearing current suspicions, owners are better served by incorporating these methods to establish a baseline and monitor trends. This can provide early detection of possible problems. It can also verify whether or not any installed protection methods are effective.

It is important to understand that both of these test methods require very specialized equipment and experienced people to operate the equipment and analyze the data.

Vibration analysis



Example of vibration spectrum showing Bearing Fluting"

Vibration analysis can be useful in confirming the existence of bearing fluting damage caused by EDM. The high frequency, high resolution spectrum of a bearing in the early stages of fluting damage will exhibit a “mound” of energy in the 2-4 kHz frequency range. As EDM damage continues and bearing degradation progresses, the fault energy spikes will migrate into regular bearing fault frequencies. Continuous monitoring of the vibration levels starting shortly after initial installation and start-up can provide important indications of increasing or changing energy spikes.

Voltage analysis
Measuring the actual voltage and current present on the shaft can be helpful in determining the likelihood of damage from EDM. However, since all motors have some level of voltage, one must determine at what levels is cause for alarm. Unfortunately, there is no magic number that tells whether or not a motor is “safe” from EDM damage. For one thing, there are many variables that can affect the measured data, i.e., bearing lubrication, measurement equipment & method, running speed, etc. Additionally, this method of predicting EDM damage is not an exact science. Different experts have different opinions of “safe” levels depending on their individual experiences. Many experts, however, agree that trending this data can be most helpful in identifying deviations that can indicate the beginning of a problem, the worsening of an existing problem, or the failure of an EDM protection method.

Methods of Protection
Now that we understand how bearing currents are generated and what they can do to your motor bearings, as well as a couple of ways to determine whether or not there may be a problem, you’re probably wondering how you can protect your motors.

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ARE BEARING CURRENTS CAUSING YOUR MOTOR FAILURES? (FA/117-03) (CONTINUED)

(Continued from page 11)

Protecting motor bearings from an unpredictable occurrence of bearing currents is not an exact science, but rather a process of risk assessment and cost analysis. There are certain measures you can take in order to reduce the risks — but not without additional cost. Since the occurrences are unpredictable, one has to weigh the cost of protection against the costs in the event that the problem was to arise.

For example, installing a shaft grounding assembly in each of 15 direct-coupled fans with 100-HP motors would be much cheaper than replacing those 15 motors three months after start-up. On the other hand, replacing 15 smaller 3-HP motors would be much less expensive, so waiving the extra cost of shaft grounding assemblies might be an acceptable risk.

If protection is warranted, the following recommendations are a few of the most frequent that have been used successfully in various industries and applications.

Shielded cable
High frequency grounding can be significantly improved by installing shielded cable with an extremely low impedance path between the VFD and the motor. One popular such cable type is continuous corrugated aluminum sheath cable. There are some new third party grounding kits that are just now becoming available to install as part of the whole system. Early testing and patent applications of such kits claim to eliminate common mode voltage from the system altogether.

SHAFT GROUNDING

Grounding Brush

Grounding the shaft by installing a grounding device provides an alternate low-impedance path from the motor shaft to the motor case. This effectively channels the current away from the bearings. It significantly reduces shaft voltage, and therefore bearing current, by not allowing voltage to build up on the rotor.

One of the more popular shaft grounding devices is a grounding brush. Grounding brushes can be custom fit to virtually any motor shaft, and can also be retrofit to existing installations. They do, however, require replacement every few years depending on the shaft rotating speed, brush tension, and motor duty.

INSULATED BEARINGS

Insulated bearings eliminate the path to ground through the bearing for current to flow. But, installing insulated bearings does not eliminate the shaft voltage, which will still find the lowest impedance path to ground. This can potentially cause a problem if the path happens to be through the d riven load or through some other component.

In order to direct the shaft voltage to ground through an acceptable path, one could install a shaft grounding device in addition to the insulated bearings. Obviously this combination is better than one or the other independently, but at a much higher cost. Again, careful risk and cost analysis can help determine the extent of protection most appropriate for your situation. Insulated bearings tend to be rather expensive, and usually have substantial lead-times from suppliers.

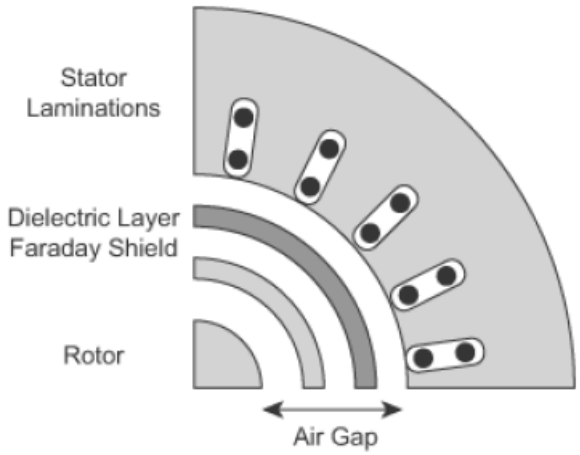
Insulated Bearing

(Continued on page 13)

ARE BEARING CURRENTS CAUSING YOUR MOTOR FAILURES? (FA/117-03) (CONTINUED)

(Continued from page 12)

FARADAY SHIELD



Electrostatic Shielded Induction Motor (ESIM) with Faraday shield

Placing grounded conductive material, such as copper foil tape or copper paint, in-between the rotor and the stator creates a Faraday Shield, resulting in an electrostatic shielded induction motor (ESIM). This method reduces the capacitively coupled currents crossing the motor air gap, minimizing the motor shaft voltage. One drawback to the Faraday shield is that the construction methods to obtain the desired benefits are very precise, which result in a higher cost motor.

Responsibility

Naturally, nobody wants to pay for repairs that follow damaging bearing currents if and when they do occur. And, spending extra money on protection methods for a problem that may or may not exist may be difficult to swallow in these days of tight budget considerations. Determining exactly where those responsibilities lie has been the topic of countless heated debates, many of which have resulted in costly litigation to settle the responsibility and cost issues.

After EDM damage occurs, some people contend that associated repairs fall within the jurisdiction of the motor warranty, while others claim that it's a warranty issue with the VFD manufacturer. To the contrary, it should not be considered as a warranty issue at all. A warranty claim implies a defect in material or workmanship. Bearing current damage can, and has, occurred in systems in which both the motors and drives were without defect.

During the early stages of a project, deciding if and how to implement protection methods is the ultimate responsibility of the owner. However, the system designers, engineers, equipment suppliers, and other players in the project are responsible for providing the owner with accurate and reliable information upon which an informed decision can be made.

Clearly, installing both the VFD and the motor from the same manufacturer narrows the number of parties involved, which would certainly make a responsibility debate easier; however, it does not necessarily prevent the situation from occurring in the first place. There are many factors outside the two individual components that can cause or promote bearing currents. For this reason, assigning ultimate accountability for a motor and VFD problem is difficult.

Recommendations

The best way to protect yourself and your equipment is to understand the causes and effects of EDM damage in order to make informed decisions during the specification, requisition and installation stages. While there is no magic recipe to follow, in this article we offer some guidelines that at the very least will bring these issues to light for discussion and consideration.

Conclusion

In contemplating these and others' recommendations, it is important to carefully consider the entire system and all of the possible current paths. This is important both in trying to predict where problems would be most likely to occur, as well as identifying and correcting existing trouble areas.

Damaging bearing currents can occur in any VFDcontrolled motor application, and will eventually cause catastrophic motor bearing failure. The motor bearings are damaged when accumulated shaft voltage discharges through the bearing causing an EDM effect. When and where bearing currents will become a problem is still unpredictable, although things such as high carrier frequency, constant speed operation and inadequate grounding can increase the risk and accelerate damage.

(Continued on page 14)

ARE BEARING CURRENTS CAUSING YOUR MOTOR FAILURES? (FA/117-03) (CONTINUED)

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Suspicions of EDM damage can be verified by special vibration analysis techniques. Determining the likelihood of EDM damage in an existing application can be assisted by special voltage analysis to find possibly damaging current loops.

If bearing currents are a problem in your installation, or if the calculated risks are high enough, you can protect your equipment by using one of several methods, either independently or in combination. The most popular and successful methods include shaft grounding devices, insulated bearings, and Faraday shields.

Determining whether or not protection is warranted and determining the appropriate methods of protection is a shared responsibility based on cost analysis and risk assessment. Educating ourselves and each other about the cause, effect and protection of bearing currents is the best line of defense.

Recommendations and guidelines		
For...	**Recommendation:**	**Notes**
Every VFD Application	Set carrier frequency <6kHz	The lower the carrier frequency the better
	Specify VFD model with carrier frequency adjustability increments no larger than 1kHz	Fine tune to the lowest acceptable level
	Shortest possible conductor lengths	Reduces reflected wave current
	Shielded cable with continuous low-impedance ground path from the VFD to the motor	Various 3rd party grounding systems are immerging in the market
< 25 HP motor	Shaft grounding device	Some protection - requires maintenance
25 HP & larger motor	Insulated motor bearings or ESIM	Higher level of protection
Long lead conductor	Inductive or RCL filter	Has to be individually tuned to the application
Difficult access to motor	Insulated motor bearings or ESIM	Higher level of protection - avoid high labor for motor replacement
Motor bearing failure despite protection	Voltage analysis to locate damaging current loops	Specialized equipment & personnel required
Noisy motor bearing operation	Vibration analysis to look for signs of EDM in motor bearings	Specialized equipment & personnel required
Failed motor bearing removed from motor	Inspect motor bearing races for signs of pitting or “fluting”	Qualified motor service technician required

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24	FRANKLIN	SUSIE HUTSLER	70	RUSH	CAROLYN CHAPPELL
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To add dates to this section, contact any Small Systems Committee Member.

November 1, 2012 – Water Works Operator Certification Examination. Application must have been postmarked by September 17, 2012. Contact: Ruby Keslar, IDEM, 317-234-7431, rkeslar@idem.in.gov or Denny Henderson, 317-234-7429, drhenders@idem.in.gov

November 7, 2012 – Indiana Rural Water Association / InAWWA Small Systems Committee – Lifting Hydrants – Turning Valves – Patching Pipe Workshop – Huntington, Indiana. Contact: Odetta Cadwell at 317-402-7349; MaryJane Miller at 866-895-4792 (toll free); or visit the IRWA website at www.indianaruralwater.org

November 8, 2012 – InWARN Generators 101 & Emergency Response Plans Workshop – Bainbridge. Contact: Jaimie Foreman at jforeman@carmel.in.gov or visit the InAWWA Website at www.inawwa.org

December 3, 2012 – Indiana Water Monitoring Council – 2012 Symposium – Drought: Is Indiana Ready For The Next One? – Indiana Government Center South, Indianapolis, Indiana. Contact: www.inwmc.org

December 3 – 5, 2012 – Indiana Rural Water Association – 2012 Water Institute (Fall Conference) – Clarion Conference Center (formerly Holiday Inn); Columbus, Indiana. Contact: Odetta Cadwell at 317-402-7349; MaryJane Miller at 866-895-4792 (toll free); or visit the IRWA website at www.indianaruralwater.org

December 11, 2012 – InWARN Generators 101 & Emergency Response Plans Workshop – New Castle. Contact: Jaimie Foreman at jforeman@carmel.in.gov or visit the InAWWA Website at www.inawwa.org

February 12 – 14, 2013 – Indiana Section American Water Works Association – Annual Conference – Indianapolis, Indiana. Contact: InAWWA at 866-213-2796 (toll free); or visit the InAWWA website at www.inawwa.org

March 3, 2013 – Indiana Rural Water Association – Pumps 101 for Water & Wastewater – Connersville, Indiana. Contact: Odetta Cadwell at 317-402-7349; MaryJane Miller at 866-895-4792 (toll free); or visit the IRWA website at www.indianaruralwater.org

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Please visit AWWA's website (www.awwa.org) for additional information regarding continuing education and professional development offerings. Materials and instruction are available through a variety of media, from traditional seminars to online courses, teleconferences, and webcasts.