Methods and techniques to ensure compliance of paper machine steam heated dryers

BY B. BURNS, B. PELLETIER AND F. ELBERT

Abstract: The aging of paper machine dryers is a concern for every owner. Through proper evaluation and maintenance of steam heated dryers, the life of these pressure vessels can be extended and reliability improved. As equipment exceeds its useful life, replacement equipment must be properly specified. This paper addresses specific requirements and recommendations for dryer inspection, maintenance, and specification of new equipment in North America, but the basic principles apply to dryers operated worldwide.

PAPER MACHINE DRYERS are manufactured in North America per ASME code for unfired pressure vessels. Similar design and manufacturing codes exist around the world, but generally have the same requirements for design, material, and fabrication. Each dryer has to be designed to resist not only the stresses induced by steam pressure, but also those stresses induced by operation of the machine. These factors include machine speed, felt tension, water loading, and sheet tension. Functional considerations for new dryers include:

• Location within the section
• Type of bearings
• Framework design
• Rope groove location and geometry

These functional considerations are important to identify in the specification process as they can have an affect on price and delivery. A typical paper machine dryer specification is shown in Appendix 1.

PAPER DRYER CERTIFICATION

Modern dryers should always be supplied with proper certification. Although some jurisdictions, ie: states in the U.S. and provinces in Canada, do not yet require certification per the ASME code or appropriate Canadian Registry, it is standard industry practice to supply vessels so certified. Even used dryers should be supplied with a recognized ‘pedigree’. This information is supplied with all new vessels and should be maintained for the life of the dryer. Additionally, the ASME “U” stamp will be attached to each vessel along with appropriate information. Included on this nameplate is the National Board Number for the vessel and the Canadian Registry Number (if required) for the design. Each vessel has a unique National Board Number while all dryers built to the same design will have the same Canadian Registry Number.

Repairs and alterations require additional information and will have a new tag attached to the dryer upon completion of the change. A summary of dryer certification information is listed in Table I.

NON-DESTRUCTIVE EVALUATION (NDE)

Dryer non-destructive evaluation is conducted per published standards. The standard for paper machine testing is TAPPI Information Paper (TIP) 0402-16. This standard identifies the minimum recommended inspection for dryer cylinders. The standard recommends a complete examination of each dryer cylinder every five years. Problems identified during the recommended inspections might require monitoring and further testing of problem areas on a more frequent basis. There are a wide range of service providers that offer NDE. It is always a good policy to have the supplier validate their capabilities on a spare dryer, if possible. This will ensure accurate results when testing the dryers installed in the machine. A short list of considerations when searching out suppliers includes:

• Personnel are certified on the various inspection methods per ASNT
• Supplier has appropriate vision exams on all inspectors per ASNT
• Supplier has experience inspecting dryer cylinders
• Supplier is familiar with TAPPI TIP 0402-16; ask to see a sample report

Visual inspection.

Visual inspection is the most important part of the total dryer examination. This includes entry of the dryer, when possible, and should include photographs of internal and external surfaces. Basic visual inspections can take place more frequently than a complete NDE because they can be done with mill personnel in a relatively short period of time. An annual visual inspection will help identify any problems with the dryer and internal equipment. The visual inspection can result in identification of several defects, as shown in Table II.

Ultrasonic thickness (UT) readings of the shell wall.

Ultrasonic thickness readings along the length of the shell will determine worn or thin spots in the shell that are potentially dangerous or do not meet the requirements of the ASME Boiler and Pressure Vessel Code. This type of measurement makes use of ultrasonic waves that travel through the shell and reflect back to the transducer. Based on the type of material and the time it takes to return to the transducer, an accurate thickness measurement is obtained. The newest equipment available...
Magnetic Particle Testing (MT).

Magnetic particle testing will locate discontinuities at the surface or slightly sub-surface by orienting magnetic particles along discontinuities that break the induced magnetic field. Wet fluorescent magnetic particles tend to be the most sensitive. This test is done under a black light; recent black light technology has eliminated the need to block out ambient light. Wet particle testing will take longer than dry particle testing, but the more sensitive result is worth the extra time involved. External inspection of dryer heads is the most common MT performed on dryers. However, MT can be performed on dryer shells and the inside surfaces of dryer heads to identify potential problems in high stress areas. Defect identification is especially difficult in MT inspections. It takes a skilled technician to differentiate a manufacturing flaw (such as a cold lap or shrinkage) from operational defects (such as cracking).

The recommended number of scans for each dryer cylinder is two, equally spaced around the dryer, unless the dryer cannot be entered, in which case four scans are necessary. Each scan should be continuous along the face of the dryer so that grooves are not missed. The shell thicknesses are usually recorded in graphical fashion, with the thinnest wall thickness driving the allowable pressure for the shell. Additional thickness readings should be done to accurately locate grooves and erosion found during the longitudinal scans and to accurately locate isolated areas of concern found during the internal and external inspections.

For projects relative to pressure increase, pressure verification, or jurisdictional acceptance, it might be necessary to complete four continuous scans, regardless of the ability to gain entry into the dryer.

TABLE I. Dryer certification information.

<table>
<thead>
<tr>
<th>Item</th>
<th>Critical Information</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>U1A data sheet</td>
<td>All design information on the dryer to include dimensions, materials of construction, and maximum allowable working pressure</td>
<td>Shipped with equipment</td>
</tr>
<tr>
<td>U1A data tag</td>
<td>“U” stamp, National Board stamp, National Board Number, CRN, serial number, and MAWP</td>
<td>Tending side head of dryer-usually a nameplate attached to the head. Older dryers have information stamped directly into the head. Shipped with equipment</td>
</tr>
<tr>
<td>U2A data sheet</td>
<td>Supplied with any replacement dryer part (head or shell). Similar information as the U1A data sheet</td>
<td>Attached to replacement heads or stamped in replacement shell</td>
</tr>
<tr>
<td>U2A data tag</td>
<td>“U” stamp, CRN, serial number, and MAWP</td>
<td>Supplied separately</td>
</tr>
<tr>
<td>R2</td>
<td>Documents modifications done to dryer.</td>
<td>Attached to tending side head</td>
</tr>
<tr>
<td>R2 data tag</td>
<td>“R” stamp, mfgs unique National Board certification number, MAWP, and date altered</td>
<td></td>
</tr>
</tbody>
</table>

TABLE II. Non-destructive evaluation (NDE).

<table>
<thead>
<tr>
<th>Defect</th>
<th>Cause</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal grooving</td>
<td>Loose or broken siphon equipment, loose or broken balance weights,</td>
</tr>
<tr>
<td></td>
<td>loose or broken dryer bars</td>
</tr>
<tr>
<td>External grooving</td>
<td>Improperly set dryer doctors, non-oscillating dryer doctors</td>
</tr>
<tr>
<td>Steam leaks</td>
<td>Loose inspection covers, failed inspection cover gaskets, failed</td>
</tr>
<tr>
<td></td>
<td>bolted connected between head and shell</td>
</tr>
</tbody>
</table>


<table>
<thead>
<tr>
<th>Customer/Location:</th>
<th>Mill Contact:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date Proposal Required:</td>
<td>Date to Install:</td>
</tr>
<tr>
<td>Paper Machine Number:</td>
<td>Quantity Required:</td>
</tr>
<tr>
<td>Dryer Diameter:</td>
<td>Dryer Face:</td>
</tr>
<tr>
<td>Bearing Centerline Distance (if known but not required):</td>
<td>Code Requirement (circle all): ASME/CE</td>
</tr>
<tr>
<td>Machine Speed/Balance Grade (circle one): Paper Dryer</td>
<td>Yankee Dryer</td>
</tr>
<tr>
<td>Dryer Diameter:</td>
<td>Anti-friction; Bearing Size</td>
</tr>
<tr>
<td>(check all that apply)</td>
<td>CARB</td>
</tr>
<tr>
<td>Anti-friction; Bearing Size</td>
<td></td>
</tr>
<tr>
<td>(check all that apply)</td>
<td>Heavy Doctored</td>
</tr>
<tr>
<td>Plain; Journal Diameter (if known)</td>
<td>Coated or Plated (circle type) plasma / chrome / Teflon</td>
</tr>
<tr>
<td>High; Journal Diameter (if known)</td>
<td></td>
</tr>
<tr>
<td>Anti-friction; Bearing Size</td>
<td></td>
</tr>
<tr>
<td>(check all that apply)</td>
<td></td>
</tr>
</tbody>
</table>

Ultrasonic testing of dryer bolts.

Each bolt of the dryer should be tested for cracks. As with thickness measurements of shells, the UT equipment must be calibrated correctly during bolt testing. Broken bolts should be removed immediately and replaced with ASME code certified bolts. Mills should be prepared to remove bolts that have broken completely off during removal. Socket head bolts cannot be
reliably tested for cracks, since the concave surface at the bottom of the socket causes the ultrasonic waves to diverge.

**USED EQUIPMENT AND RECONDITIONING**

There are numerous opportunities to find used equipment on the market. However, the challenge becomes one of finding equipment that fits the existing machine constraints. Considerations relative to suitability of used equipment in an existing machine include:

- Bearing type, size, and centerline
- Dryer diameter
- Head style

Should dimensionally correct dryers be found, ability of the dryers to operate at the desired steam pressure must be determined. It would be prudent for the potential new owner to obtain the most recent NDE results, all the code paperwork, and conduct a visual inspection of the dryers prior to making a financial commitment. Although correct code paperwork is a good indication of suitability for use, many dryers have seen rough conditions that make them undesirable. Appendix 2 is a suggested list of items to verify when considering used equipment.

Often mills have dryers that have been taken out of service. Many of these dryers have some reuse potential. A quick evaluation can be made of these ‘boneyard’ dryers, using the same criteria as for used equipment, Appendix 2. Remember that replacing heads or reconditioning these

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**APPENDIX 2. Used Dryer Inspection Checklist.**

Paper Machine Number:

CRN:

Inspector:

Dryer Documentation.

These should be available at the time of inspection.

Dryer Diameter-use pi tap and measure at three locations across dryer face. One 12 from each end of the dryer and one in the middle.

Dryer Shell. General condition of dryer surface. Is there any evidence of doctor grooving or damage caused by removal of wraps? Is there any visible crazing of the surface or accumulation of dirt? Is the surface pitted?

Take picture of general surface condition and specific problem areas.

Dryer Head-Tending Side. Is there any evidence of cracking, grinding, pitting, disoloration, or other damage? Are any head bolts missing or appear to have non-standard bolts. Take picture of general surface condition and specific problem areas.

Dryer Journal-Tending Side. Is there any evidence of cracking, grinding, pitting, disoloration, or other damage? Are any head bolts missing or appear to have non-standard bolts (for bolt on journals only)? Are any of the radii between journal diameters damaged or scored? Are bearing or seal fits damaged or scored? Take picture of general surface condition and specific problem areas.

Dryer Head-Drive Side. Is there any evidence of cracking, grinding, pitting, disoloration, or other damage? Are any head bolts missing or appear to have non-standard bolts. Take picture of general surface condition and specific problem areas.

Dryer Journal-Drive Side. Is there any evidence of cracking, grinding, pitting, disoloration, or other damage? Are any head bolts missing or appear to have non-standard bolts (for bolt on journals only)? Are any of the radii between journal diameters damaged or scored? Are bearing or seal fits damaged or scored? Take picture of general surface condition and specific problem areas.

**Dryer Number:**

**National Board Number:**

**Inspection Date:**

**U1 or U1A data sheets**

**U2 or U2A partial data sheets for any replacement components (heads/shell)**

**Data plates fastened and readable**

**Most recent nondestructive testing report**

**Any special Jurisdictional documentation or reports**

**Tending Side**

**Drive Side**

**Middle**

**OK**

**Doctor Grooving**

**Crazing/cracking**

**Dirt/buildup/rust (circle one)**

**Surface pitted**

**Other damage (describe damage and location)**

**Cracking**

**Grinding (note depth from surface to bottom of grind)**

**Pitting**

**Discoloration**

**Bolts missing (note location)**

**Non-standard bolts (note location and marking on bolt head)**

**Other damage (describe damage and location)**

**Cracking**

**Grinding (note depth from surface to bottom of grind)**

**Pitting**

**Discoloration**

**Journal radii damaged**

**Bearing fit damaged**

**Seal fits damaged**

**Bolts missing (note location)**

**Non-standard bolts (note location and marking on bolt head)**

**Other damage (describe damage and location)**

**Cracking**

**Grinding (note depth from surface to bottom of grind)**

**Pitting**

**Discoloration**

**Journal radii damaged**

**Bearing fit damaged**

**Seal fits damaged**

**Bolts missing (note location)**

**Non-standard bolts (note location and marking on bolt head)**

**Other damage (describe damage and location)**
Dryers for other sections of the machine are viable options. Dryers that are of no use should be scrapped to avoid accidental reuse and potential catastrophic failure.

**RE-RATING, ALTERATIONS, AND REPAIRS**

By definition, an alteration is any change from the original Manufacturer’s Data Report (UD1), which affects the pressure-containing capability of the pressure-retaining item, as per Appendix 4 of the 2004 NBIC. These include nonphysical changes, such as an increase in the maximum allowable working pressure of the vessel.

Dryer re-rating is possible with code dryers, but nearly impossible with un-coded dryers or dryers of unknown origin. The potential for pressure increase can often be determined prior to any on-site testing by reviewing the original pressure vessel documentation and running some simple calculations. Many times this preliminary review shows that the dryer cannot be re-rated. If the preliminary review shows potential for re-rating to a higher pressure, nondestructive examination is conducted. The NDE is more comprehensive than the TAPPI recommendation. Once the NDE is finished, the results are evaluated to determine the new possible working pressure. Variables that must be considered when evaluating the potential pressure are:

- Head and shell material
- Head thickness and shape
- Shell wall thickness
- Felt tension
- External dryer loading
- Soundness of all dryer bolts
- Machine speed

Pressure verification is the next step after the calculations. Traditionally, this has been by a hydrostatic pressure test. Each dryer to be tested must first be filled with water. The dryer is pressurized to the required pressure (two times the working pressure for re-rating) and held at pressure for 10-30 minutes while being observed for leaks. Care should be taken to ensure that the weight of a full dryer or series of dryers does not damage the framing or dryer journals. The time to complete hydrostatic testing of dryers is a function of the number of test fixtures, the size of the dryers, the number of personnel, and the method of filling the dryers.

Some jurisdictions are now accepting acoustic emissions (AE) testing as a substitute for pressure verification by hydrostatic test. Using this technique, structural defects in the vessel can be ‘heard’ by the use of sensors and data processing equipment. AE offers a viable alternative in situations where hydrostatic testing is too difficult to perform - as long as the jurisdiction approves the test method.

After successful completion of the pressure verification test, the proper tags are applied to the dryer. The mill will receive a complete copy of the appropriate pressure vessel code work for their records. Mills should not become disillusioned with the results of re-rating. The new pressure could be lower than the current operating pressure, since dryer defects might be identified during NDE. Re-rating can only be accomplished by a company that has an “R” stamp issued by the National Board of Boiler and Pressure Vessel Inspectors. Re-rating requires validation of the entire process by the performing company’s authorized inspector (AI). In addition, the mills pressure vessel insurer often is required to oversee the process and it is always a good idea to have the jurisdiction involved.

A repair is the process of returning the vessel back to a safe operating condition. A typical repair is installing a sleeve on a dryer journal that has had a spun bearing. Repairs require design calculations to ensure that the modifications do not exceed material and code limits. It is essential to get the original equipment supplier involved to ensure proper assessment of the repair.

**STORAGE OF PAPER MACHINE DRYERS**

The recommended storage area for new dryers is a dry, low humidity, dust-free storage room. The wooden skid used for transportation can be used for storage purposes as well. If dryers have to be stored outside, take paper wrapping off the dryers to prevent the creation of water pockets between paper and dryer shell. Add protective coating material to all surfaces that can have contact with water. Occasionally check surfaces for possible scratches and/or spots on the protective coating and recoat if needed. Remove bearings and bearing assemblies for long-term storage.

Even equipment removed from the machine should be carefully stored for future use. The surface of the dryer can be damaged by storing the dryer directly on the ground. Used equipment should be stored in a similar fashion to new. This will reduce reconditioning costs should the equipment be put back in service.

**TIPS FOR LONG TERM HEALTH OF YOUR PAPER MACHINE DRYERS**

- Regular nondestructive testing program; trend the data collected
- Fix all steam leaks immediately
- Proper warm-up procedures
- Proper cool-down procedures
- Never spray dryers with water or other liquids when hot
- Never weld on a cast iron dryer
- Only repair a dryer under the supervision of a reputable OEM

**CONCLUSION**

Paper machine dryers should last a long time if proper operation and maintenance guidelines are applied. Accurate record keeping and timely inspections give a good picture of the current condition and will indicate planning timelines for maintenance, repair, or replacement of aging equipment. If equipment replacement becomes the only option, then understanding the key dryer cylinder parameters is critical for new equipment specification and successful installation. Dedicated attention during the life of steam heated paper dryers will ensure continued compliance with established pressure vessel standards and result in the operation of safe, reliable equipment.

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**Résumé**: Le vieillissement des séchoirs des machines à papier présente un problème pour leurs propriétaires. En procédant à une évaluation et à un entretien appropriés des séchoirs à vapeur, on peut prolonger la vie de ces appareils à pression et améliorer leur fiabilité. Lorsque l’équipement dépasse sa durée de vie utile, il faut bien préciser la nature de l’équipement de remplacement. La présente communication traite des besoins particuliers et des recommandations en matière d’inspection, d’entretien, et de spécification des nouveaux équipements en Amérique du Nord, mais les principes de base s’appliquent à tous les séchoirs utilisés partout dans le monde.


**Keywords**: DRIERS, PAPER MACHINES, MACHINE DESIGN, STEAM, REGULATIONS, SPECIFICATIONS, MAINTENANCE, INSPECTION,