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Guidelines for inspection and nondestructive testing of paper machine dryers

Scope

This Technical Information Paper (TIP) provides guidelines for inspecting cylindrical, steam-heated pressure vessels made from gray cast iron (GCI) and used as rotating dryers in papermaking. These guidelines also apply to unheated GCI cylinders of the same construction, but large yankee dryers typically used on tissue machines are not covered. Most dryer cylinders made in North America after 1950 were designed and manufactured in accordance with ASME Boiler & Pressure Vessel Code, Section VIII (1).

These guidelines cover inspection only of the dryer pressure vessels. While inspection of related steam and condensate piping, relief valves, bearings and drive components, and doctoring devices is not covered, the inspector should report unusual symptoms and conditions in the components so they can be combined with other inspection findings of the dryers in “running” and “idle” mode (defined below), to prioritize dryers for inspection when they are in the “out of operation” mode (i.e., during an outage). This document complements the TAPPI publication, *Guidelines for the Safe Operation of Steam Heated Paper Machine Dryers* (2).

This TIP does not describe how to assess the significance of damage revealed by inspections. In that regard, API579-1/ASME FFS-1 “Fitness for service” (3), which is accepted by the National Board of Inspectors, provides post-construction code rules for assessing fitness for service of pressure vessels, including a dryer with corrosion, wear or crack damage. Guidelines in this TIP do not supersede local jurisdictional and regulatory requirements.

Safety precautions

Personal safety for inspectors is ensured by complying with standard mill procedures for lockout and safe entry of a confined space. A dryer must be cool and adequately ventilated, as confirmed by oxygen testing. Inspectors and NDT technicians shall use the specified personnel protective equipment (PPE).

Outline

The following issues are discussed in more detail below:

- Damage mechanisms
- Inspection planning

TIP Category: Automatically Periodically Reviewed (Five-year review)



Documents

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- Inspection frequencies
- Inspections performed in each operational mode
- Qualifications for inspection personnel and nondestructive testing (NDT) technicians
- Documentation of findings

This document describes inspections performed while a dryer is in one of the following modes:

- Running (in normal operation)
- Idle (temporarily stopped)
- Out-of-service (shutdown) (stopped, cooled and open for internal inspection).

Background information

Most cast iron dryers have three main components: a cylindrical shell and two bolted heads, each with a journal (see Fig. 1). The shell is a cast cylinder with an internal flange at each end bolting the heads. Each head has three integral elements: hub journal, dish-shaped head and flange for bolting the head to the shell. The head on the tending side (TS) is not the same as the head on the driven side (DS). The journal may be part of the head casting or a bolted or shrunk journal made of steel or ductile iron. ("Unicast" dryers have heads integrally cast with the shell.)

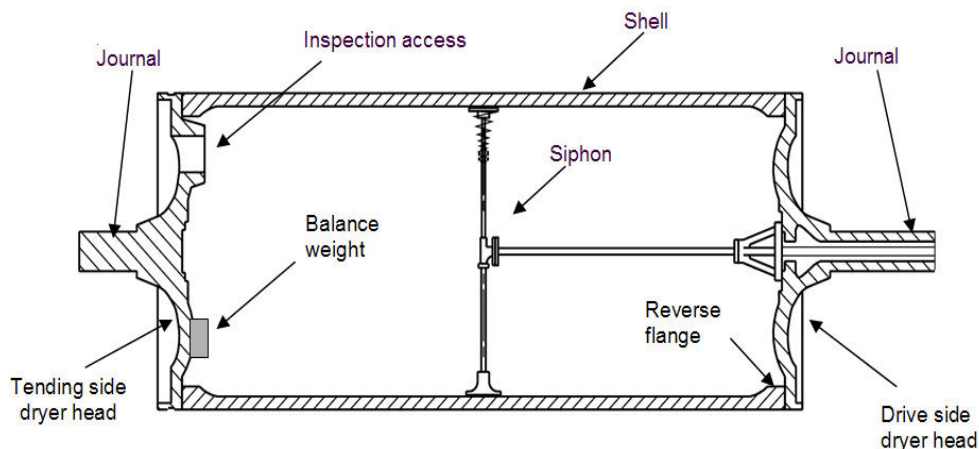


Fig. 1. Dryer cross-section (other siphon designs also are used).

Because gray cast iron is inherently brittle it fails with no deformation or visible deformation from overstress. However, the graphite flakes in GCI reduce its sensitivity to mechanical notches, providing relatively high tolerance for cracks and linear flaws.

As described later, variations in the metallurgical structure of GCI require special precautions for successful ultrasonic testing. The inspection and NDT methods recommended in these guidelines generally apply to dryers made from other materials, including ductile iron and carbon steel.

Damage mechanisms

Most of the catastrophic dryer failures resulted from grooves worn in the shell by loose hardware tumbling inside the dryer. Fatigue cracking in or around the journal and in the heads is another significant concern. Cracks also have resulted from severe thermal shock due to dousing a hot dryer with water, even if the water is warm. Uneven heating of a dryer on startup (e.g., if the dryers are not rotating when steam is supplied) increases the probability of thermal shock, distortion and cracking.

Consistent and proficient application of the inspection methods described in this TIP typically find the following damage symptoms that are most likely to compromise a dryer's mechanical integrity:

1. Thinning of the shell, locally due to internal tumbling wear, or uniformly from external doctoring wear.

2. Cracking of the head, around the journal and openings and in and near the head flange.
3. Cracking or failure of the bolts holding the heads on the shell.

Groove thinning from “tumbling wear” occurs when loose components rolling around inside the dryer wear a circumferential groove into the shell. *It is important to be alert for symptoms of this mechanism, e.g., unusual noises coming from the dryer, on every running mode inspection.* Localized internal shell thinning from condensate erosion can occur around improperly positioned siphons. External wear typically involves grooving, scoring and scraping on doctored dryers.

Cracks that grow usually are from fatigue. (The cracking mechanism in GCI is hard to identify by fractography.) Fatigue cracks, which occur where high levels of cyclic stress are locally concentrated by flaws and sharp surface shapes, mostly affect the journal, the head around the opening, and the head flange. Fatigue cracks are more likely in the head’s external surface but cracks can grow from corners and flaws on the internal surface.

An inspection goal is to find cracks small enough for safe removal by grinding. API579-1/ASME FFS-1 contains analytical procedures for assessing the significance of cracks and the grooves made to remove them, as well as other damage in the dryer. (Cast iron can be repaired by plugging in a code-approved procedure.)

Bolt cracking

Carbon steel bolts joining the head to the dryer shell may crack. The mechanism is believed to be stress corrosion cracking (SCC), namely carbonate/bicarbonate SCC of bolts contacted by steam condensate. Many bolts in a head can be affected. SCC typically is associated with steam leaks, which are both a symptom and a potential cause of cracked bolts.

Inspection planning

Five crucial tasks in planning dryer inspections are:

1. Establish an inspection plan that covers all the dryers.
2. Review past inspection or condition information.
3. Identify specific dryers to inspect next. Results from inspecting all the dryers, from both the tending and drive sides, in both running and idle modes, are crucial in identifying dryers for detailed internal inspection when the dryers are next out-of-operation. Steam leaks, indications of condensate flooding, new noises from a dryer and condensate flooding are obvious reasons a specific dryer should be internally inspected at the next opportunity. Other reasons to inspect a dryer include drive or bearing problems, and incidents of thermal shock from application of a cold water stream or a fire.
4. Arrange for trained and qualified inspectors, and written procedures: ‘walk-down inspections’ when dryers are running or idle should be done by mill personnel trained to identify the critical symptoms and conditions listed above. Only appropriately qualified NDT technicians (see Appendix A) should inspect and do NDT for internal thinning, head cracks and cracked bolts. Qualified mill personnel can do NDT but paper mills typically hire NDT companies to do comprehensive inspections. Whenever feasible, a standard with known flaws (e.g., a dryer head with cracks) should be used to qualify the NDT procedure and the proficiency of the NDT technician before NDT is done on the dryers.
5. Formally document all inspections, except routine daily or weekly ‘walk-down inspections’ of dryers in running or idle mode by machine operators. (See Appendix B and Appendix C).

Inspection frequencies

Running and idle modes

Routine ‘walk-down inspection’ of a dryer section should be done every day or two. Formal, documented inspection in both run and idle modes, with a checklist for each dryer, should be done every month or two.

Out-of-service (shutdown) mode

General industry practice is to comprehensively inspect an open and cool dryer at least once every five years. The interval between “out-of-service” inspections for a specific dryer should be adjusted for appropriate condition-based circumstances: cracks or other questionable conditions may warrant more frequent inspections. The default five-year inspection interval also may be extended if a longer inspection interval is based on engineering evaluation and risk assessment and if routine walk-down inspections do not indicate sooner inspection is required.

Factors to consider in establishing the inspection frequency for a specific dryer include:

- The known condition of the dryer’s principal components
- The dryer’s maintenance history, especially problems with bearings or internal components
- Operating conditions, especially if rotational speed or dryer section pressure are increased (rerated)
- Condition of internal components other than siphons
- Recent dryer washdown, wrap removal and fire fighting incidents

Inspection practices

Running mode (normal operation)

The inspector should perform and document a systematic, walk-down inspection on the tending and drive sides of the dryer sections, checking for the following:

- Active steam leaks
- Unusual dryer noise or motion
- Unusual dryer temperature (use infrared thermography (IRT), which could indicate problems with steam supply or condensate drainage)
- Excessive shaking, rocking or swaying of a dryer frame; loose or cracked structural supports

NOTE 1: Undesirable conditions must be brought to the immediate attention of the maintenance department.

The main purpose for inspecting operating dryers is to detect early signs of problems or distress that could affect dryer reliability, thereby identifying dryers for detailed follow-up inspection during or before the next planned machine shutdown. The inspector should record all significant observations on a formal inspection report.

Idle mode (briefly stopped)

The main purpose for inspecting dryers that are idle is similar to a running mode inspection: to detect early signs of problems that could lead to dryer failure, and identify dryers for detailed follow-up inspection. When dryers are idle, e.g., during brief machine outages, a trained inspector should systematically ‘walk-down’ the tending and drive sides, using good lighting to look for the following indications and evidence:

- Steam leaks, including stains and deposits especially in the bolt circle
- Missing head bolts/studs
- External wear or impact damage
- Excessive lube oil leakage or other signs of bearing distress
- Insufficient removal of condensate from the dryers (IR sensing equipment facilitates finding this)

NOTE 2: Undesirable conditions must be brought to the immediate attention of the maintenance department.