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ENGINEERING AND GINNING

A Comprehensive Gin Maintenance Program

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ABSTRACT

A comprehensive gin maintenance program is critical to optimizing the efficiency of a ginning system and affects labor, energy, and maintenance costs; safety, downtime, daily throughput, fiber properties, and customer satisfaction. A comprehensive gin maintenance program includes a sound maintenance philosophy, downtime and repair documentation and guidelines, a dormant season repair program, ginning season preventive maintenance, and a ginning season repair program. Implementing a comprehensive gin maintenance program in dormant and ginning seasons will minimize the frequency and length of downtime. This will maximize throughput, reducing energy and labor costs per bale, benefitting both the gin's customers and its owners. Example downtime, inspection, repair and preventive maintenance reports are provided.

The assets operated by a cotton gin are expensive, specialized equipment. To neglect preventive maintenance and timely repairs squanders the gin company's investment. To keep each part of the ginning system well maintained and operating properly maximizes the benefit received by the gin's owners and customers. This requires a commitment on the part of the directors and managers to prioritize maintenance; it also requires a commitment on the part of employees and vendors to perform maintenance properly.

A comprehensive gin maintenance program contributes to the bottom line and could be the difference between profitability and financial loss for cotton gins. The success of a cotton ginning operation is determined in part by how efficiently its machinery processes raw seed cotton into marketable products (packaged lint, seed, and byproducts). A comprehensive gin maintenance program is critical to optimizing ginning system efficiency and affects safety; downtime; daily throughput; labor, energy, and maintenance costs; and customer satisfaction.

A comprehensive gin maintenance program includes planning, communication, and continual documentation. Each employee has a role to play that is interrelated with that of his or her coworkers, from office staff compiling downtime and repair data, seasonal employees performing cleaning and preventive maintenance, gin crew members operating equipment and detecting and troubleshooting problems and planning repairs, and management overseeing the entire operation while satisfying the customer's need for timely, quality ginning. Because it involves every employee, and because each employee's responsibility affects that of other employees, there must be a universal commitment to the maintenance program that includes two-way communication and appropriate training at all levels. A comprehensive gin maintenance program has four basic components: (1) a sound maintenance philosophy, (2) downtime and repair documentation and guidelines, (3) a dormant season repair program, and (4) a ginning season preventive maintenance and in-season repair program.

A SOUND MAINTENANCE PHILOSOPHY

For a comprehensive, effective repair program, gin management must adopt and communicate to all employees a sound, year-round philosophy. That philosophy is simply that to reduce in-season downtime a gin must be kept clean, adjusted routinely, have wear parts replaced, and, if something breaks, be repaired properly the first time. Sufficient time and resources must be devoted to proper maintenance and repair.

DOWNTIME AND REPAIR DOCUMENTATION AND GUIDELINES

The repair, downtime, and preventive maintenance history must be tracked and used in planning the needed dormant season repairs and in justifying machinery and plant modifications. The general downtime and preventive maintenance reports provided (Figs. 1, 2) are for illustrative purposes, and

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could be useful in developing a maintenance program for a specific gin. The most important thing is documentation of the gin's performance, individual machinery problems, and the type of repairs performed. Written guidelines should emphasize management's commitment to quality repair and should direct the activities of seasonal employees who might be unfamiliar with gin machinery.

Guidelines for a sound repair program during the ginning season include:

- Make time during operation to clean during or between shifts.
- Make time during or between shifts to perform inspections by competent employees trained to detect problems before they cause lengthy shutdowns.
- Perform preventive maintenance on a routine basis.
- Shut down the gin (if possible) before making repairs.
- Take time to think about how to do the repair safely.
- Lock out and tag out power before working on any machine, dissipate stored energy (e.g., capacitors, compressed air, or springs) and support anything that might fall.
- If the gin is shut down for a repair, have crew members not involved in the repair perform preventive maintenance elsewhere.
- Stock an adequate supply of common repair parts and materials.
- Repair machinery properly the first time.
- Maintain a log of downtime for all repairs (Fig. 1) and a log of all maintenance performed (Fig. 2).

A DORMANT SEASON REPAIR PROGRAM

A dormant season repair program should enable the ginner to make repairs in an organized and thorough manner, thus minimizing in-season downtime. Priority can be given to machines that caused the most trouble by compiling downtime reports and preventive maintenance logs. Whether downtime reports are compiled on paper (Fig. 3) or automatically by gin software (Figs. 4, 5), this documentation is crucial to set priorities for preventive maintenance and to uncover systems that need modification and machines that need replacement to minimize the risk of future downtime. If necessary, this same documentation can be used to justify larger repair and replacement expenditures to the gin's board of directors or bank.

Downtime Report Date:_____ Time:_____

Equipment Code (circle one)	Hours:Minutes	Reason Code (circle one)
001 Module Feeder	_____:_____	01 Belts
002 Unloading Hopper (or Separator)	_____:_____	02 Sheaves
003 Feed Control	_____:_____	03 Chains
004 Vacuum Dropper	_____:_____	04 Sprockets
005 Unloading Burner	_____:_____	05 Shafts
006 Rock Catcher	_____:_____	06 Bushings
007 Tower Dryer	_____:_____	07 Bearings
010 Unloading Fan (Side: __)	_____:_____	08 Gears
011 1st Hot Air Cleaner (Side: __)	_____:_____	10 Scrolls
012 Stick Machine (Side: __)	_____:_____	11 Screens
013 Vacuum Dropper (Side: __)	_____:_____	12 Grids
014 Second Stage Burner (Side: __)	_____:_____	13 Ribs
015 2nd Stage Pull Fan (Side: __)	_____:_____	21 Saws
016 2nd Hot Air Cleaner (Side: __)	_____:_____	22 Brushes
017 Vacuum Dropper (Side: __)	_____:_____	23 Rollers
018 Gravity Cleaner (Side: __)	_____:_____	24 Cylinders
020 Conveyor Distributor	_____:_____	25 Flashing
021 Automatic Overflow System	_____:_____	30 Pipes
030 Extractor Feeder (Number: __)	_____:_____	31 Valves
031 Gin Stand (Number: __)	_____:_____	40 Conveyors
032 Air Jet Cleaner (Number: __)	_____:_____	50 Control Panel
033 Lint Cleaner (Number: _____)	_____:_____	51 Motor Control Center
034 Lint Cleaner Fan (Number: _____)	_____:_____	52 Motor
035 Battery Condenser	_____:_____	53 Other Electrical
036 Battery Condenser Fan	_____:_____	60 Hydraulic System
040 Moisture Restoration Unit	_____:_____	70 Pneumatic System
041 Hot Air Unit	_____:_____	
050 Lint Slide/Feeder/Tramper	_____:_____	80 Choke-up
051 Bale Press, Pump, or Control Valves	_____:_____	
052 Bale Strapper	_____:_____	81 Fire
053 Bale Handling & Weighing System	_____:_____	
060 Trash Dropper (Location: _____)	_____:_____	90 Cotton
061 Trash Auger (Location: _____)	_____:_____	Switchover
062 Trash Stacker	_____:_____	91 Out of Cotton
070 Seed Dropper (Location: _____)	_____:_____	92 Module Truck
071 Seed Scale	_____:_____	93 Bale Mover
072 Seed Blower	_____:_____	94 Mistagged Bales
080 Mote Fan	_____:_____	95 Trash Hauling
081 Mote Cleaner	_____:_____	96 Labor Shortage
082 Mote Press	_____:_____	97 Power Failure
090 Cyclones (Location: _____)	_____:_____	98 Weather
999 Miscellaneous _____	_____:_____	99 Other: _____

Figure 1. Example downtime report (paper). To be completed every time the gin stops.

Preventive Maintenance Report Date:_____ Time:_____

Equipment Code	Hours:Minutes	
001 Module Feeder	_____:_____	Ginner's Name: _____
002 Unloading Hopper (or Separator)	_____:_____	Bypass? (circle) Yes No
003 Feed Control	_____:_____	
004 Vacuum Dropper	_____:_____	Reason Code (circle)
005 Unloading Burner	_____:_____	01 Belts
006 Rock Catcher	_____:_____	02 Sheaves
007 Tower Dryer	_____:_____	03 Chains
010 Unloading Fan (Side: __)	_____:_____	04 Sprockets
011 1st Hot Air Cleaner (Side: __)	_____:_____	05 Shafts
012 Stick Machine (Side: __)	_____:_____	06 Bushings
013 Vacuum Dropper (Side: __)	_____:_____	07 Bearings
014 Second Stage Burner (Side: __)	_____:_____	08 Gears
015 2nd Stage Pull Fan (Side: __)	_____:_____	10 Scrolls
016 2nd Hot Air Cleaner (Side: __)	_____:_____	11 Screens
017 Vacuum Dropper (Side: __)	_____:_____	12 Grids
018 Gravity Cleaner (Side: __)	_____:_____	13 Ribs
020 Conveyor Distributor	_____:_____	21 Saws
021 Automatic Overflow System	_____:_____	22 Brushes
030 Extractor Feeder (Number: __)	_____:_____	23 Rollers
031 Gin Stand (Number: __)	_____:_____	24 Cylinders
032 Air Jet Cleaner (Number: __)	_____:_____	25 Flashing
033 Lint Cleaner (Number: _____)	_____:_____	30 Pipes
034 Lint Cleaner Fan (Number: _____)	_____:_____	31 Valves
035 Battery Condenser	_____:_____	40 Conveyors
036 Battery Condenser Fan	_____:_____	51 Motor Control Center
040 Moisture Restoration Unit	_____:_____	52 Motor
041 Hot Air Unit	_____:_____	53 Other Electrical
050 Tramper	_____:_____	60 Hydraulic System
051 Press	_____:_____	70 Pneumatic System
052 Strapper	_____:_____	
053 Bale Handling System	_____:_____	Circle One:
060 Trash Dropper (Location: _____)	_____:_____	
061 Trash Auger (Location: _____)	_____:_____	X Inspection
062 Trash Stacker	_____:_____	A Adjustment
070 Seed Dropper (Location: _____)	_____:_____	B Lubrication
071 Seed Scale	_____:_____	C Cleaning
072 Seed Blower	_____:_____	D Repair
080 Mote Fan	_____:_____	E Replacement
081 Mote Cleaner	_____:_____	F Other: _____
082 Mote Press	_____:_____	
090 Cyclones (Location: _____)	_____:_____	
100 Vehicles (Specify: _____)	_____:_____	

Figure 2. Example preventive maintenance report (paper). To be filled out after every shift.

Downtime and Preventive Maintenance Summary

Equipment and Reason	Freq.	Downtime (hours) Shift 1	Shift 2	Shift 3	Freq.	Preventive Maintenance (hours) Shift 1	Shift 2	Shift 3	Freq. Total
000 None									
81 Fire	13	2.0	5.0						13
94 Mistagged Bales	1			2.0					1
95 Trash Hauling	3	6.0							3
97 Power Out/98 Weathr	1		3.5						1
001 Module Feeder									
C Cleaning					12	6.0			12
03 Chains – A Adjust					1	0.5			1
04 Sprockets – B Lube					1	0.5			
07 Bearings – E Replace	1	1.5			1	2.5			2
012 Stick Machine									
80 Choke-up	5	0.5	1.5	0.5					5
01 Belts – E Replace					1			1.0	1
017 Vacuum Dropper									
03 Chains – B Lubricate					3	1.0			3
25 Flashing – E Replace	1			2.0	1			2.0	2
030 Extractor Feeder (#3)									
11 Screens – A Adjust					1	1.0			1
031 Gin Stand (#1)									
52 Motor – E Replace					1	1.0			1
031 Gin Stand (#2)									
80 Choke-up	2	1.0							1
035 Battery Condenser									
11 Screens – D Repair					3			1.5	3
040 Moisture Rest'n Unit									
xx Lime Scale – C Clean					3	3.0			3
052 Strapper									
A Adjustment	12	2.0	1.0	3.0	6	2.0			18

Figure 3. Example paper summary of preventive maintenance and downtime reports.

Downtime Report Detailed **Your Gin Here**

Thursday, December 01, 2018 Report for period from: 09/1/2018 8:20:40 AM through: 12/1/2018 8:20:40 AM

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Downtime Reason:	Bale:	Tag Flag:	Date/Time of Bale	Minutes Down:
SGH Machine	701550	S	11/13/2018 07:01	30.00
	701622	S	11/13/2018 09:54	33.33
	701638	S	11/13/2018 11:01	27.27
	701640	S	11/13/2018 11:32	25.00
	701672	S	11/13/2018 13:02	66.67
	701688	S	11/13/2018 14:40	35.29
	701695	S	11/13/2018 15:30	28.57
	701734	S	11/13/2018 17:16	27.27
	701781	S	11/13/2018 19:16	75.00
	702271	S	11/14/2018 14:51	10.34
	710876	S	11/27/2018 15:51	75.00
	Downtime Min.:	**Downtime Hours:**	**Total Occurrences:**	**% of Downtime**
	433.76	7.23	11	3.05%

Downtime Reason:	Bale:	Tag Flag	Date/Time of Bale	Minutes Down
Inclines	681566	S	10/15/2018 13:46	24.00
	690132	S	10/27/2018 11:42	13.04
	692327	S	10/30/2018 19:05	13.04
	693689	S	11/01/2018 16:42	20.00
	710895	S	11/27/2018 17:44	13.04
	711330	S	11/28/2018 08:28	12.50
	711387	S	11/28/2018 10:35	22.22
	712195	S	11/29/2018 13:53	11.11
	712834	S	11/30/2018 13:22	33.33
	Downtime Min.:	**Downtime Hours:**	**Total Occurrences:**	**% of Downtime**
	162.30	2.71	9	1.14%

Figure 4. Example automated downtime report (sample EAGL.SYS detailed downtime report by courtesy of Lubbock Electric Co., Lubbock, TX).

Downtime Report Summary **Your Gin Here**

Thursday, December 01, 2018 Report for period from: 09/1/2018 8:20:40 AM through: 12/1/2018 8:20:40 AM

Downtime Reason:	Occurrences:	Avg. Min. Per Occurrence:	Downtime Min.:	Downtime Hours:	% of Downtime:
Operator	449	31.6	14185	236.4	68.71%
Clean Up	41	100.6	4125.78	68.8	19.98%
Press	19	30.8	584.33	9.7	2.83%
Burr House	3	113	338.9	5.6	1.64%
Condenser	8	37	296.1	4.9	1.43%
Module Feeder	23	10.9	250.1	4.2	1.21%
No Cotton	10	22.7	227.1	3.8	1.10%
1A Incline	13	13.3	172.93	2.9	0.84%
Bagger	7	20.5	143.27	2.4	0.69%
Ginstand 1	1	50	50	0.8	0.24%
Strapper	3	16.7	49.97	0.8	0.24%
2A Incline	3	11.7	35.02	0.6	0.17%
Ginstand 3	3	9.6	28.88	0.5	0.14%
1st Stage Pull Fans	1	28.6	28.57	0.5	0.14%
2nd Stage Burners	1	26.1	26.09	0.4	0.13%
1B Incline	3	8.1	24.32	0.4	0.12%
Hull & Seed Conveyor	2	11.5	23.08	0.4	0.11%
2B Incline	1	10.9	10.91	0.2	0.05%
Lint Cleaner Fans	1	10.7	10.71	0.2	0.05%
#2 Lint Cleaners	1	10.3	10.34	0.2	0.05%
Ginstand 4	1	9.1	9.09	0.2	0.04%
Feed Control	1	7.4	7.41	0.1	0.04%
Ginstand 2	1	7.1	7.06	0.1	0.03%
Total Time:	98150.03	**Downtime Min.:**	20644.94	**Percent Down:**	21.03%
Total Hours:	1635.8	**Downtime Hours:**	344.1		

Figure 5. Example automated downtime report summary (sample EAGL.SYS downtime report summary by courtesy of Lubbock Electric Co., Lubbock, TX).

Lint Cleaner Inspection Checklist

Condenser	Check for holes, worn flashing, bent wire, bad bearings, cracked staves and misalignment
Fluted Doffing Roller	Replace end seal; check wear and flashing
Smooth Doffing Roller	Check tension on roller; replace end seals; check wear and flashing
Feed Rollers	Check clearance and tension spring
Feed Bar	Check clearance and check for wear
Grid Bars	Check clearance and check for wear
Saws	Check for tooth damage, dull teeth, and unwinding
Air Doff	Check air gap on doffing hood
Brushes	Check for wear, breaks, and clearances
Windboard	Check air gap
Tension Arm	Check springs
Lights	Check bulbs, wiring and connections
Idler Pulley	Check for wear, make sure pulley turns easily
Belts	Check for cracks, stretching and burning
Sheaves	Check alignment and bushings; make sure sheaves are not worn
Chains	Check slack and lubrication
Sprockets	Check for worn teeth and check bushings
T-Flashing	Check for wear and burning
Windows	Check for leaks and missing or broken panes
Guards	Check for missing or broken guards
Miscellaneous	

Figure 6. Example inspection checklist for a lint cleaner.

A dormant season repair program is a team effort involving management and year-round gin personnel. The team should start at one end of the gin and systematically work their way through to the other, inspecting each machine and its supporting systems in turn. This team should have guidelines for checking each machine and a list of all parts that are required by that machine. This type of documentation is sometimes available from the manufacturer (Figs. 6, 7).

Parts List and Repair Checklist

Gin Location: _____ Date: _____ Page ___ of ___

Hardwicke-Etter 840 Challenger Lint Cleaner (Model Number 95-10161)

Repaired by:	Part No.	Parts Description	Task Description	Quantity	Cost/ Item	Extension
	38-10322	1-7/16 Fafnir RCJT bearing		4		
	38-10314	Bearing Housing LC-82-A		2		
	38-10312	Bearing Housing LC-81-B-R		1		
	38-10313	Bearing Housing LC-81-B-L		1		
	35-10101	Fafnir RA-107NPP Bearing		3		
	38-10192	Fafnir RASN 1-15/16 Bearing		2		
	35-10018	Fafnir RA-103NPP Bearing		2		
	77-10048	¾ O.D. 1-1/2" Comp Spring		4		
	18-10022	4-7/16" x 6-7/16" Glass		2		
	14-10058	5/8 x 5/8 x 68-1/2 Felt Ring		2		
	49-10680	7/64 x 2-1/2 x 79-5/8 Flashing		4		
	92-14416	Brush Sticks		28		
	77-10044	1-3/16 O.D. 2" Comp Spring		4		
	38-10365	Pivot Bearing		4		
	38-10382	1-7/16 Feed Roller Bearing		2		
	38-10316	Fafnir LCJ 2-7/16" Bearing		2		
	38-10317	Fafnir RAS 2-7/16" Bearing		2		
	25-10127	20-tooth Gear C-109-1-7/16"		1		
	25-10106	15-tooth Gear C-108-1-7/16"		2		
	25-10017	15-tooth Gear C-108-1-3/16"		1		
	92-13159	15-tooth RC-60 Idler Sprocket		1		
	33-60152	15-tooth RC-Sprocket		3		
	39-10142	SH-Bushing 1-7/16" bore		3		
	18-10014	Window Glass		1		
	92-16406	18-tooth RC-50 Idler Sprocket		2		
	33-50605	60-tooth RC-50 Sprocket		1		
	33-50182	18-tooth RC-50 Sprocket		1		
	33-50303	30-tooth RC-50 Sprocket		1		
	33-10233	16-tooth RC-50 Type-B Sprocket with 1-7/16" bore		1		
	33-60325	32-tooth RC-60 Sprocket		1		
	92-14304	15-tooth RC-60 Sprocket Cap		1		

This equipment has been repaired and is ready for operation. Date: _____

Ginner: _____ Manager: _____ Superintendent: _____

Figure 7. Example repair checklist and parts list for a specific machine.

DORMANT SEASON INITIAL INSPECTION

The dormant or repair season begins with an assessment of the entire ginning system, first by compiling downtime reports, then by physical inspection. The following general inspection list is not intended to be complete, but rather to serve as guidance as you prepare a detailed inspection list specific to the equipment in your gin.

The gin depends on mobile equipment to keep it supplied with raw material and to remove finished goods. Module trucks, yard trucks, water trucks, module handlers, fork lift trucks, man lifts, bale movers, and all other mobile equipment need to have tires, belts, hoses, and fluids checked. All regular service interval items such as tune ups, changing motor oil, replacing hydraulic oil, and replacing air and fuel filters, brake pads, belts, etc. should be completed before the vehicle is needed. If vehicles are serviced in-house, parts can be ordered; if vehicle servicing is hired out, it should be scheduled before the vehicles are needed again. The truck scale, bale scale, and seed scale(s) need to be serviced, inspected, and certified annually as well.

Module feeders need to have every shaft and bearing inspected. Worn, bent, or missing dispersing cylinder drum spikes need to be replaced. Inspect drive components (discussed in the power transmission equipment section, below). Inspect safety emergency stop devices and limit switches for feed rollers (or walking floors), access doors, and, if present, the round module unwrapping system, tarp baler, conveyor belts, augers, feed control cylinders, and vacuum droppers or high-slip dryers. Do not overlook the pneumatic cylinders (if so equipped) on rock and green boll traps; test them for leaks and drain the air lines. See the Cotton Ginners Handbook section "Seed cotton unloading systems" (Funk and Wanjura, 2017). As with all equipment, consult the manufacturers' manuals for correct settings.

For pneumatic conveying systems repair and adjustment is important because their fans consume more than half of the electrical energy a typical gin uses (Funk and Hardin IV, 2017) and they determine the operating velocity of the dust cyclones, which determines their performance (Funk et al., 2000). Check every fan wheel for wear and balance. Inspect drive components. Inspect all ducts for damage, wear, and leaks and repair and seal as required. Measure air flows to verify that each system has the correct air volume and velocity and be sure that the cyclone system is still in compliance with your emissions permit. Keep a record of air velocities for future reference. Consider hiring a consultant who specializes in cotton gin air flow management if you had airflow problems last season or recent modifications have altered airflow requirements. Consider replacing blast gates with variable frequency drives for systems that have blast gates. See the Cotton Ginners Handbook sections on pneumatic handling systems and air pollution abatement (Anthony and Mayfield, 1994) and "Using cyclones effectively at cotton gins" (Whitelock et al., 2009).

Separators need to be checked for any tagging, and the cause corrected. Inspect grid sections, screens, and stationary flashings for damage, replacing as required. Check all moving parts (drive components, bearings, shafts, rollers, wipers,

flashings, and spiked drum cylinders) and repair or replace whatever is misaligned, worn, or broken. All vacuum droppers, including those handling seed and trash, and those outside the gin building, need to be inspected for alignment, and for damage or wear to the main flashings, side flashings, scrolls, shafts, bearings and drives. Any component that is misaligned, bent, worn, damaged, or missing must be fixed. For example, if the end flashings were not replaced on one side, the resulting air leak could result in inadequate conveying leading to a choke-up. See the Cotton Ginners Handbook sections on pneumatic handling systems and "Seed cotton unloading systems" (Funk and Wanjura, 2017).

Seed cotton drying systems impact fiber quality because pre-cleaning equipment effectiveness and fiber damage done at the gin stand are determined by seed cotton moisture content. Test the gas pressure to the drying system burners to make sure it is at least 35 kPa (5 psi) when all burners are on. If propane is used, make sure the regulated pressure leaving the storage tank(s) is not more than 100 kPa (15 psi) to avoid re-liquification in the underground line to the gin building (Samuel Jackson, 1990). Frost on the outside of fuel pipes indicates liquid propane inside. Make sure burners are clean, flames have the right fuel/air mixture, fire when ignited, and stay lit when the control system signals for heat. For example, a long yellow flame indicates excessive gas pressure or inadequate air flow near the burner, and failure to stay lit could indicate low gas pressure. Check drying system controls to make sure they are programed correctly and set point and high limit sensors are in the correct location (ASAE, 2007), are not damaged, and are reading the temperature accurately (Styrofoam cups full of boiling water and ice water can be used for a simple calibration). Example: High limit should not be more than 177° C (350° F) (Anthony, 2006). Examine all ducts, remove or polish smooth all points where tags formed, and seal any leaks. Inspect dryer, inline cleaner, and hot air cleaner access/cleanout doors to make sure they fit well and seal properly. See the Cotton Ginners Handbook section on moisture control (Anthony and Mayfield, 1994).

It is much easier to remove foreign matter in the pre-cleaning stage, before particles are reduced in size by the gin stand, than at the lint cleaner. Seed cotton cleaning and extracting equipment (cylinder cleaners, bur and stick extractors, stick machines, extractor feeders, and in some cases, impact cleaners) need to have every shaft and bearing inspected. Bent shafts; worn bearings; worn, bent, or missing cylinder cleaner drum spikes and grid bars or screen sections, and extractor and stick machine rough or corroded grid bars; worn, bent, or missing channel saws; and worn or missing doffing and stationary brushes need to be replaced. Damaged or ill-fitting doors, lids, and access panels also need to be replaced; this is especially critical on hot air cleaners, which can be under 5 kPa (20 in. W.G.) of negative pressure, because a small gap results in a large amount of air leakage, increasing the electric bill. Stationary brushes and doffing brushes should touch the base of the channel saw teeth. Grid bar clearances need to be checked against manufacturer's specifications and adjusted if necessary. For example, the distance between the grid bar and the saw cylinder can be correct at the ends, but the bar needs to be warped in the middle by turning the internal hex (Allen) screws in the mounting plates. Note also that clearances for the same model are different for different machine widths. See the Cotton Ginners Handbook section on seed cotton cleaning and extracting (Anthony and Mayfield, 1994).

Gin saws should be checked for worn or broken teeth, and projection through, and alignment with, the ribs. Depending on conditions, saws generally are replaced after ginning 12,000 to 24,000 bales per stand, but foreign objects can damage saws quickly, so it is wise to keep a spare saw mandrel on hand during the ginning season. Doffing brushes should touch the bottom of the saw tooth; when worn brushes are replaced the doffing cylinder must be dynamically balanced. Inspect inside the gin stand for buildup of insect sugars (honeydew) and fine particles. Doffing is sensitive to airflow, so make sure the seals on upper moting chambers, doors, access panels, and viewing windows are effective. Gin stand breast lateral adjustment should place the saws in the center of the rib slots. There should be 6-mm (¼-in.) clearance between the back of the ribs and the saws when the breast is out. Label the breast if it is removed, so it can be replaced on the same gin stand. Some models of gin stands require checking other adjustments (seed fingers, huller ribs, picker rollers); proper drive belt tension and saw mandrel rotational speed are critical and must be set to the manufacturer's specifications. See the Cotton Ginners Handbook sections "Saw gin stands" (Hughs et al., 2017) or "Roller ginning" (Armijo et al., 2017).

The lint cleaner has been responsible for more accidents than any other machine in the gin. It is

essential to inspect guards and safety interlocks to ensure that your employees will be safe. Lint cleaning equipment inspection includes looking for tags in the condenser and associated ductwork and ensuring that airflow between the gin stand and the lint cleaner is between 8 to 10 m/s (1,500-2,000 fpm). Airflow can be measured using a pitot tube when there is no lint in the duct. See the Cotton Ginners Handbook section on pneumatic conveying (Anthony and Mayfield, 1994). Check the condenser screen drum for dents, holes, or misalignment. For example, the screen drum could have a dent in it from a choke-up, and therefore it now drops lint into the feed works unevenly, compromising throughput and cleaning effectiveness. Check flashings and cleanout doors for air leaks. Warped, worn, or damaged feed rollers and bars, and worn or damaged saw cylinders should be replaced. Dull grid bars should be sharpened (Baker and Brashears, 1989) and set to manufacturer's specified clearance across the width of the machine. Inspect the doffing brush and get it dynamically balanced if brush bars are replaced. Lint cleaner brushes should just clear the tips of the saw teeth on the spiral-wound saw cylinder. See the Cotton Ginners Handbook section on lint cleaning (Anthony and Mayfield, 1994).

Proper moisture restoration can greatly reduce the energy required to press a bale. Check the moisture restoration systems' water treatment systems, boilers, pumps, fans, duct work, valves and sensors for lime scale, leaks, and proper functioning, or ask the manufacturer to provide field service. See the Cotton Ginners Handbook section on moisture control (Anthony and Mayfield, 1994) and consult the manufacturer's manual for detailed instructions.

The battery condenser must send a uniform lint batt to the bale press for it to make a uniform bale. Check the battery condenser screen drum for dents, holes, or misalignment, check the flashings for wear and leaks, and inspect the doffing roller condition. Make sure the lint slide is clean and smooth. Check the feed mechanism limit switches, guides, and drive components, clean if dirty, adjust if improperly tensioned or misaligned, and replaced if worn or broken.

The bale press is a crucial part of any cotton gin because its failure results in a plant shutdown. Due to the forces involved in bale formation, component failure can also be life-threatening. Check that the press frame and ram are level and plum, all fasteners are secure and shims are in place, boxes align with tramper and ram, and door locks and turn latch are in good condition. For example, make sure that the strain rod retaining nuts are tight. Send a sample of the press unit's hydraulic oil to a laboratory to be tested for contamination and remaining useful life (your oil vendor might provide this service). Filter all new oil before adding it to any hydraulic system. Check seals and O-rings on cylinders and valves. Make sure that there are plenty in your spare parts inventory; it would be inefficient to have the gin stop because of a part costing only a few dollars. Check that hydraulic hoses and pipes are secure and free of leaks. Replace oil filters. See the Cotton Ginners Handbook section on packaging lint cotton (Anthony and Mayfield, 1994).

Bale strapping, handling, sampling, and bagging systems are becoming increasingly complex and sophisticated; manufacturers' field service representatives might need to assist with inspection. Make sure safety devices and optical and mechanical limit switches are secured, adjusted, and working correctly, and all drive components are aligned, tensioned, and lubricated according to the manufacturer's instructions. See the Cotton Ginners Handbook section on packaging lint cotton (Anthony and Mayfield, 1994).

Air compressor tanks and air lines need to be drained of water and compressed air lubrication systems supplied and functioning properly. Consult the manufacturers' manuals for additional service instructions. Listen for air leaks when no other equipment is running and fix all leaks—leaking air costs money. Replace filters, hoses, and air nozzles as required.

Inspect the conveyor distributor and seed and trash handling belts and augers, including the ones under the floor, under the cyclones, and over the trash pile. See the Cotton Ginners Handbook section on mechanical handling systems for more detail. Check cyclones for wear and leaks, replacing components as necessary (Whitelock et al., 2009). Check seed tubes for leaks and wear and the seed blower for proper functioning. See the Cotton Ginners Handbook section "Cottonseed air-handling and storage requirements" (Ashley et al., 2018).

Mote handling, cleaning, and packaging systems need to be inspected including their limit switches and control units. Trash stacking equipment and seed pile roof and aeration system (if so equipped) also require inspection.

Take time to think about the entire ginning system, to include every part in your gin on the inspection list. Pay special attention to any component of

the ginning system that is unique, such as the module feeder, the bale press, or the trash stacker. Failure of a component that you only have one of will result in stoppage of the entire gin. Make sure the inspection list captures components that might have contributed to things on the downtime report. For example, be sure to check the flashings on the vacuum dropper located under the separator if it choked up several times during the last season.

After the inspection, the team can estimate the cost of the repairs and determine if the repairs indicated on the repair checklist will solve the problems identified on the downtime report. The repair checklist allows the ginner to obtain all the parts needed for the machines requiring repair in one purchase. This allows the ginner to concentrate on repairing one or two machines at a time without waiting for parts to be delivered. Repairing only one or two machines at a time reduces the risk of parts becoming mixed up or getting lost.

DORMANT SEASON REPAIRS

Guidelines for a repair program during the dormant season include:

- Keep the gin clean and safe.
- Lock out and tag out power before working on any machine, dissipate stored energy (e.g., capacitors, compressed air or springs) and support anything that might fall.
- Consult the manufacturers' manuals or web sites for service intervals, adjustment settings, and detailed instructions.
- Spend the money to make repairs properly so that in-season downtime is minimized.
- Repair machinery that otherwise might not make it to the end of the next ginning season.
- Plan to have replacement parts and specialized repair tools (and rental equipment, if needed) on hand.

DORMANT SEASON MOTOR CONTROL CENTER MAINTENANCE

Typical cotton gin voltages and currents can cause catastrophic damage and are potentially deadly. More than two-thirds of electrical system failures can be prevented by a routine preventive maintenance program (Hartford Steam Boiler, 2014). The dormant season inspection process should include the electrical system. The motor control center is at the heart of the gin's control and distribution of electrical energy. The motor control center contains disconnects that allow for the safe isolation of individual motors, mechanical and/or solid-state devices that start the motors, and, increasingly, variable frequency drives that control motor function and devices that allow for monitoring motor performance.

Because of the complexity of modern motor control center components and the specialized tools and training required to maintain and test them, and because of the potential liability associated with a possible failure, motor control center preventive maintenance must be performed by an experienced NETA (InterNational Electrical Testing Association) certified contractor who is insured to perform this task. As with all cotton gin machines and systems, predictive maintenance during the dormant season and preventive maintenance during the ginning season reduce costly downtime. And as with other cotton gin machines and systems, if not more so, motor control center maintenance reduces the risk of property damage, serious injury, or death and it is essential to engage a competent contractor.

Dormant season inspection is distinct from the inspection that can be performed only while the motors are operating under full load (below), but it is just as important. Dormant season inspection is performed on de-energized equipment. Inspecting de-energized equipment requires specialized training, especially in safety. All main power and control circuit power must be disconnected, verification made that there is no electrical potential, and temporary grounding devices installed.

While all power is locked out, the contractor will inspect the motor control center enclosures for combustible materials, moisture, and dirt. They will clean components, including ventilation openings and grills, with brushes and vacuums and seal off those places where moisture or dirt and trash came in. They also will verify that all seals and gaskets are still effective. If they find any signs of water, they could ask gin personnel to identify the source and permanently correct the situation.

While cleaning each component the contractor will inspect them for signs of damage from corrosion, heat, tracking, and arcing. They will replace, or direct the gin's licensed electrician to replace, badly worn contacts and damaged components with parts that are the correct rating. They will also verify that replacement fuses are the correct size, amperage, and delay.

After examining each conductor near the place where it makes a connection, looking for signs of heat damage to the insulation (Fig. 8), the contractor will tighten all connections to the torque value specified by the equipment manufacturer. They should also check all splices for signs of heat damage and repair as necessary. Depending on the design of the motor control center, it might also be necessary to tighten bus bar supports and connections.

Additionally, the contractor will inspect each lever that operates a disconnect to make sure that they function, move freely without binding, and do not hit any wires. As they manually close each breaker they will check for proper wipe, pressure, contact blade alignment, and synchronization. They will also make sure that lock out-tag out components prevent motion that would result in the circuit inadvertently becoming energized.

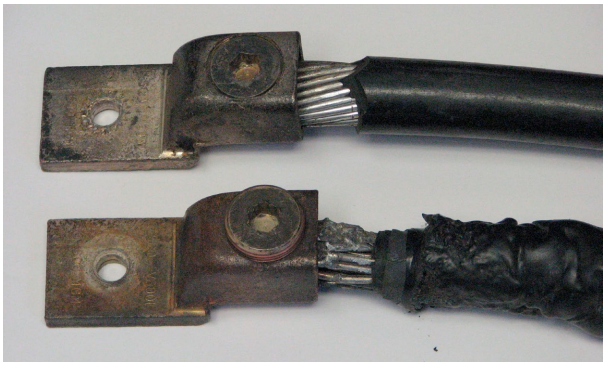

Figure 8. Example of signs of heat damage (bottom conductor).

GUIDELINES FOR BOTH DORMANT SEASON AND GINNING SEASON

Before starting any machine repairs, document the location of sheaves and sprockets and the path of belts and chains, by sketches or photos (e.g., use your phone) so that shafts turn the correct speed and direction after reassembly. Care should be taken to ensure that adjustments are set according to the manufacturer's recommendations. If a machine has been causing problems, check the manufacturer's manual to be sure changes were not accidentally introduced during a prior repair. Verifying that shaft speeds are what the manufacturer intended can be done using a tachometer (basic tachometers cost less than $200).

Manufacturer's manuals provide all the necessary information to properly adjust and maintain their products. If the original manuals cannot be located, contact the manufacturer to order replacement manuals. Be sure that the manual being used is not just for the model but also for the width machine being serviced; as an example, 3.6-m (12-ft)-wide seed cotton cleaners have greater grid bar-to-cylinder clearances than identical models that are only 2.4 m (8 ft) wide.

POWER TRANSMISSION EQUIPMENT

Almost all cotton gin machinery has either a v-belt or roller chain drive, and many machines have both. Every employee working on gin machinery should receive training in the proper care and repair of power transmission technology. When inspecting machinery in the dormant season or during the ginning season it is essential to stop all moving parts, dissipate stored energy, and lock out and tag out all sources of motion. All power transmission components must be guarded. Guarding by location is only effective if all machinery in that location is stopped each and every time a person enters that space. Always reinstall the guards!

V-belt life is determined by belt tension more than anything else. If a v-belt is too loose it will slip, overheat, and fail prematurely. If a v-belt is too tight, it will strain shafts and bearings, causing them to wear out. Sheave alignment is also important; if the belt enters the groove from an angle it will wear out quickly and can also wear out the sheave.

When installing V-belts:

- Dissipate stored energy, lock-out and tag-out, and secure moving parts.
- Align shafts and sheaves so belts enter the sheaves in a straight line.
- Only install belts by loosening one of the sheaves; never by prying or "rolling on," as internal cords will be broken in the process, and the belt tension will be too loose.
- Rotate the system after installing belts and before adjusting tension to be sure the belts are fully seated in all sheaves.
- Tension the belt using a force gage or other tool designed for this purpose (such as an optical vibration frequency meter), never by feel, as the feel changes depending on how the belt was made.
- Protect belts from oil and grease, never use belt dressing as it will also soften the rubber and cause the belt to fail early.
- Always reinstall the guards!

Daily inspection of belt drives includes:

- Dissipate stored energy, lock-out and tag-out, and secure moving parts.
- Check belt tension using a force gage or other tool designed for this purpose.
- Inspect belts for signs of overheating and to make sure there are no cracks or wear.
- Inspect for rubber crumbs that indicate a belt is rubbing against something or a sheave is no longer aligned.
- Check that belts enter sheaves in a straight line.
- Always reinstall the guards!

In addition to the above, dormant season inspection includes checking both inside surfaces of every sheave to make sure they are not wearing unevenly. Always reinstall the guards!

Roller chain life is determined by lubrication more than anything else. Clean oil of the correct viscosity should be directed into the clearance between the inner and outer link plates, ideally on the top side of the chain just before it wraps around the bottom of the drive sprocket. For most cotton gin applications SAE 30 or multigrade SAE 20/50 is the correct viscosity. Manual lubrication with a brush or spray can should be done every 8 hrs; that is why drip, stream, and bath forms of automated lubrication are popular. For light duty applications, self-lubricating chains with O-rings or oil-impregnated sintered bushings are available that do not require oiling.

Dormant season chain drive inspection:

- Dissipate stored energy, lock-out and tag-out, and secure moving parts.
- Remove the roller chain and measure its elongation; if it is more than 1.5% the chain needs to be replaced.
- Purchase a roller chain wear gage and use it to check the chain for wear.
- Make sure none of the joints stick. If they still stick after cleaning and re-lubricating, for example because a pin is bent, do not expect the chain to last another season, replace it!
- If the link plates have flat spots the chain needs to be replaced and the new chain protected from rubbing by installing idlers, chain guides, or wear strips.
- If the link plates have cracks, enlarged holes, or are broken, the pins are bent, or the rollers are cracked, the chain is overloaded and needs to be replaced with a higher-strength chain.
- If the rollers are gouged or pitted, or some pins are sticking out, the chain and sprockets need to be replaced and the new chain protected by proper lubrication.
- The sprockets should be replaced at the same time the chain is replaced.
- If the sprockets are worn or the teeth are not symmetrical, they need to be replaced and the new sprockets protected by correct alignment and proper lubrication.
- The chain should be replaced at the same time the sprockets are replaced.
- Always reinstall the guards!

When installing roller chain:

- Dissipate stored energy, lock-out and tag-out, and secure moving parts.
- Install chain following the manufacturer's instructions, using recommended parts and tools.
- Align shafts and sprockets so chain wraps onto the sprocket in a straight line.
- Tension the chain using the manufacturer's guidelines (deflection is based on span) or installing one of various types of chain tensioning devices.
- Consider supporting long spans with idlers or UHMW plastic guides.
- Always reinstall the guards!

When inspecting chain drives during the ginning season:

- Dissipate stored energy, lock-out and tag-out, and secure moving parts.
- Make sure the chain is clean and well oiled, but not dripping or flinging excess oil.
- Check the sprockets and chains for signs of wear.
- Check that the chain is aligned with the sprockets.
- Inspect the chain for cracked or broken link plates, protruding pins, and damaged rollers.
- Always reinstall the guards!

GINNING SEASON MOTOR CONTROL CENTER INSPECTION

Inspecting energized equipment requires specialized training, especially in safety, and specialized equipment, both thermal imaging and safety equipment. It is essential to hire an experienced NETA certified contractor. They own the specialized safety and inspection equipment, and have the training to perform an inspection safely. And their experience will help maximize gin management benefit from the data collected because they know how to interpret the results.

Energized equipment is usually inspected using infrared thermography. Images of equipment running at full load are recorded using an infrared camera. Equipment can include motors, motor control center components, and transformers and electrical service entrance equipment. Infrared images show surface temperatures, revealing components that are hot because of loose or corroded connections, overloading, unbalanced loads, or internal faults.

Repeated infrared thermography (or other temperature and current measurements) can be analyzed to reveal trends. Thermal trend analysis is more useful if thermal images are recorded at the same time of day and under the same ambient temperature and operating conditions. Abnormal temperatures often are a sign that equipment is beginning to fail. This information lets ginners plan corrective action before equipment fails, downtime occurs, or an injury takes place.

A GINNING SEASON PREVENTIVE AND IN-SEASON REPAIR PROGRAM

The success of a ginning operation is determined by how efficiently the cotton is ginned. The gin should be properly repaired and ready to operate at maximum efficiency with minimum downtime. The basic principle of preventive maintenance is reducing downtime through scheduling routine maintenance and repairs. Preventive maintenance will reduce repair costs while increasing daily production. Repair costs are reduced by doing small repairs on machinery before a part failure impacts other components and causes more extensive damage. For example, replacing a drive belt on a battery condenser when it shows signs of wear is cheaper than replacing the belt and the screen drum after it has been damaged by a choke. In addition to avoiding more extensive damage, scheduling preventative maintenance can also reduce downtime by allowing an orderly shutdown of the gin without choking. Preventive maintenance avoids more extensive damage, saves money, and reduces downtime. Sometimes it also saves digging a mess of cotton out of a choked machine.

Preventive maintenance should be scheduled regularly, according to the needs of each piece of equipment. Some machines require hourly inspection, whereas others once a day or once a week is enough. However, it is easier to have a routine, such as scheduling one hour every shift for preventive maintenance. All members of the crew must participate and have specific machinery for which they are responsible every time. Inspecting familiar machines increases the likelihood that abnormalities will be detected. After all machinery has been stopped and locked out and proper safety instructions have been given, the ginner should assign each employee to specific machinery, give each of them a preventive maintenance checklist (Fig. 9), and train each of them in what to look for. After the initial training period, the ginner will be able to concentrate on specific repair problems needing specialized attention. If a problem is discovered during the preventive maintenance period, the problem should be corrected immediately. If the parts necessary are not available to repair the machine immediately, the parts should be ordered, and the repair scheduled for the next preventive maintenance period.

Preventive Maintenance Checklist for Lummus 66/86 Lint Cleaners

Before doing the following, **lock out power and wait for equipment to stop**!

Check off each item below when completed.

___ 1. Check condenser for tagging or choking conditions and then clean condenser.

___ 2. Clean inside and outside of condenser screen drum.

___ 3. Check saw teeth and clean them if required.

___ 4. Remove dust, dirt, and loose material with high pressure, moisture-free air.

___ 5. Check trash pan, ducting, and other internal parts for foreign matter and tagging conditions; remove burrs and other causes of tag.

___ 6. Inspect and clean rubber parts (gaskets, scale, flashing, etc.)

___ 7. Check condition and alignment of belts, sheaves, chains, and sprockets, lubricating and making other corrections as required.

___ 8. Clean auxiliary feed roller.

_____ _____
Signature Date

Figure 9. Example preventive maintenance checklist for a specific machine.

Preventive maintenance is an ongoing process. The procedures to be followed depend partly on the period of gin operation. The three periods and the procedures for each period are:

1. After initial break-in period (72 hrs):

- Lock out all equipment.
- Check the condition and alignment of all sheaves, belts, sprockets and chains; tighten the set screws and bolts that maintain their alignment.
- Check for inadequate or excessive lubrication.
- Check the general appearance and condition of parts; tighten and adjust as required.
- Check entire system for any signs of excessive wear.

- Check entire flow path for any tagging that could lead to a choke-up.
- Check the interior of machines for chokes or material accumulation.
- Check for evidence of leaks and loose connections in the duct system.
- Check electrical wiring for evidence of insulation breakdown (Fig. 8).

2. During each production run:

- Observe the entire gin, including overhead, under the floor, and outside the building for a smooth, orderly flow of all materials with even distribution across all machinery.
- Observe air handling systems for leaks and loose connections.
- Wipe fuzz off air intake screens with a wad of lint.
- Record gas pressures at burner control units.
- Observe all bearings and drive components, looking for signs of misalignment, improper tension, and over- or under-lubrication, such as metal filings, rubber particles, etc. (include all processing and conveying systems).
- Listen for excessive noise or vibration, and squealing or chattering of belts, gears, shafts, chains, bearings and motors.
- Observe hydraulic units for cooling system problems, plugged filters, and leaks.
- Record temperatures of hydraulic system components (use infrared thermometer).
- Record temperatures of electrical motors (use infrared thermometer).
- Check module feeder disperser cylinders for contaminating plastic.
- Check seed cotton cleaners' and lint cleaners' discharge and trash piles for excessive cotton.
- Check seed for excessive lint and for seed damage.
- Check lint cleaner discharge for excessive seed coat fragments.
- Check lint samples for poor machine conditions (contamination, preparation, and excessive levels of trash, seed coat fragments, or neps).
- Check bales for moisture level, signs of contamination, consistent length, width, and height dimensions, symmetry, shape, strap integrity, and bag seal.

3. Between production runs:

- Lock out all equipment.
- Back out the module and check the module feeder dispersing rollers for bent or missing spikes and remove all plastic contamination!
- Check cylinder cleaners' rollers for bent or missing spikes, look for bent or missing grid bars, and remove all plastic contamination.
- Check stick machines for bent or missing channel saws and damaged or missing stationary and doffing cylinder brushes.
- Check interiors of lint condensers for screen damage, wiper damage, flashing condition, plastic, tags, and trash accumulation.
- Check inlets, outlets, trash discharge, and interiors of all machines and conveying systems for plastic, tags, trash accumulation, and worn or damaged parts.
- Check all moving parts for signs of wear (grooving, metal filings, binding).
- See the power transmission section above for drive component inspection recommendations.

Saw Gins:

- Inspect gin stand ribs for lint accumulation, misalignment, and wear.
- Inspect gin saws for bent or broken teeth and for misalignment with ribs.

Roller Gins:

- See the Cotton Ginners Handbook section "Roller ginning" (Armijo, et al. 2017).
- Check lint cleaner rollers, saw cylinders, and grid bars for damage, wear, and accumulated materials.
- Check all vacuum droppers flashing, including side flashing.
- Observe hydraulic units for cooling system problems, plugged filters, and leaks, especially in cylinders located above the bale where oil would contaminate cotton.

During the preventive maintenance process the ginner must have a method for documenting the amount of work needed on each machine. The example preventive maintenance report (Fig. 2) may be used for this purpose. The information in the preventive maintenance reports can be used to determine which dormant season repairs and machinery modifications are necessary.

ADDITIONAL TOOLS

New technologies are available that can help a ginner detect a problem early, before it becomes serious. The preventive maintenance described above is just as important when using these tools; they only serve to help detect things that might not be noticed

by workers as quickly. Among many products, some include shaft vibration sensors and associated electronics that can predict bearing failure (typically installed on large fans and high-speed cylinders) and fire detection systems and air pressure-based choke sensors specially designed for cotton gins.

CONCLUSION

Implementing a comprehensive gin maintenance program in dormant and ginning seasons will minimize the frequency and length of downtime. This will maximize end fiber quality as well as throughput, benefitting both the gin's customers and its owners.

DISCLAIMER

Mention of trade names or commercial products in this publication is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the U.S. Department of Agriculture. USDA is an equal opportunity provider and employer.

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