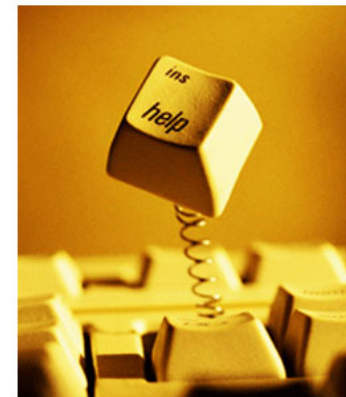


- Theory 8: Operation and Maintenance of
 - Automated Inspection Systems



- First line maintenance concept
- Preventive / Predictive /Corrective maintenance
- Holistic maintenance
- Obsolescence management

1. During building of the URS a risk assessment should have taken place, so FMEA critical functions should have been addressed
2. This must be the bases for maintenance
 - Maintenance is not only checking for wear and greasing
 - The goal is to preserve the mechanical/electrical state of the machine as was during the initial validation.
3. In fact you preserve the baseline, otherwise you cannot guarantee equality in visual inspection after
 - Machine errors
 - Breakdown of mechanical parts
 - Breakdown of electrical parts
 - Worn-out of light sources
 - Camera malfunction



You need tools for a regular check and decision making

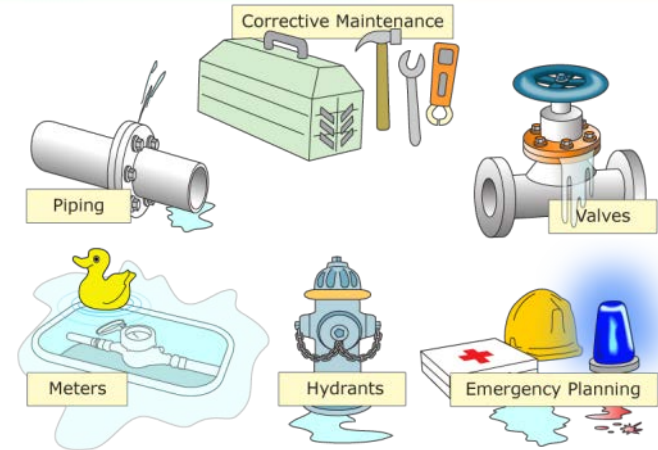
1. Tooling to adjust electrical and mechanical zero point
2. Calibration tools
 - Focus of depth and aperture of cameras
 - Light intensity light sources. LEDs will loose brightness in time and you need to define when to exchange
3. Alignment tools
 - To check for unbalanced grippers or vial holders
 - To align star wheels and other transport parts

The mechanical impact on vision is huge

- Not well aligned creates crashes, product spills
- Unbalanced grippers or holders generate false ejects



- Corrective maintenance
 - You act when something brakes down
 - Not completely unavoidable
 - Disadvantage: uncontrollable downtime



PM Preventive maintenance

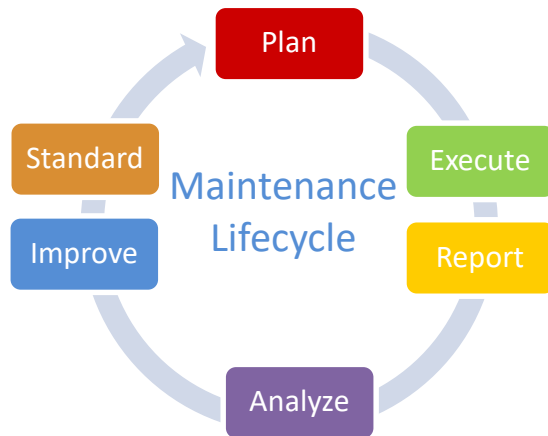
- You act before something brakes down
 - You periodically exchange parts
 - You analyze and learn. It's a cycle
- An annual schedule of daily, weekly, monthly, quarterly and yearly task to perform
 - First Line Maintenance should be part of this
 - Disadvantage: you may exchange wear parts to soon and thus extra costs

PDM Predictive maintenance

- You act when the information gathered signals it's time
- You collect this information during production with minimal production loss

Examples

- Statistically Inline monitoring of the eject rate per gripper
- Statistically Inline monitoring of the LED brightness



Best Practice

- A combination of PM and PDM
- PM has some PDM elements
- They form the maintenance lifecycle

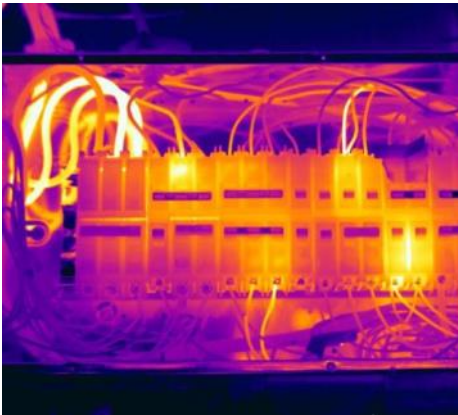
Area of maintenance

- A multi disciplinary multi departmental combined effort
 - Mechanic
 - Electric
 - Computer(management)
 - Vision



Electrical

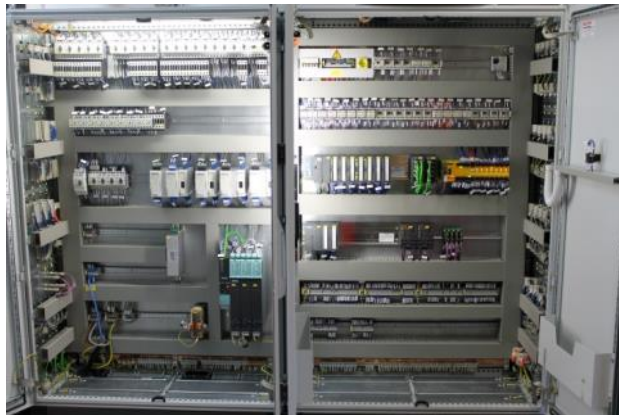
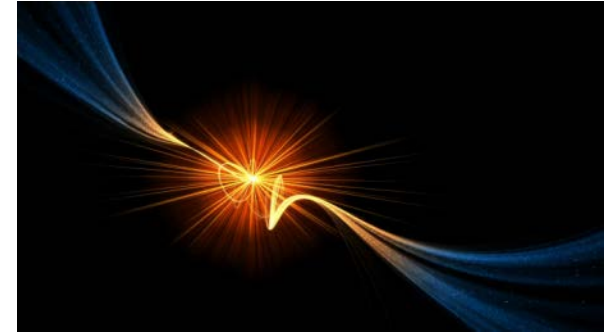
- Often seen as reliable and neglected
- The quality and reliability of electronics, sensors, PLCs etc. are very high nowadays



- Wiring is the Achilles
- Infrared measurements in the cabinet gives information
- But only for high current, a few percentage of the whole

Low current wiring

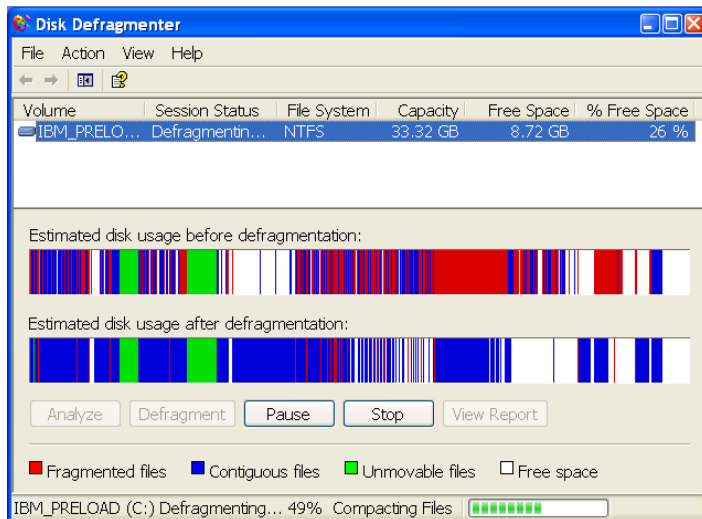
- Faulty contacts generate sparks
- Very difficult to find
- Brings your AVI in unpredictable state
 - PLC programs rely on sensor and state information



- Not everything in the design is failsafe
 - A sensor should generate an error if malfunctioning
 - or If the cable is broken
- The preventive measure can only be checking the clamps in cabinets and connection boxes annually

Modern AVI will use Intel processors to communicate with the users and organization

- Very often using the Windows operating system
- Temporary information is stored on the hard drive in huge amount
- Defect images for later usage etc. and often not removed



- What's important: frequent back-up
- What's not important: frequent clean-up
- Although the NTFS file system is more stable: Fragmentation will take place and could slow down the overall performance
- In short: don't neglect. It also needs a frequent overhaul

In short

OF LIMITS

Small unwanted changes will have huge effect

- Camera position, diaphragm, aperture
- Position LEDs, especially front light
- You can DIY, but you need special trained staff
- Depending on machine configuration cleaning is possible

- Maintenance is not just another department it should be embedded
 - Create ownership

And not

- I here a strange sound in my machine

Well, not my problem

The machine operator stands closes to AVI

- They are the ears and eyes of maintenance
- The first that should signal that something is not in order
- Unexpected machine errors and more frequent
- Involvement by feeling they are owner
- A simple way to achieve this is First Line Maintenance



- First Line Maintenance

Simple tasks that operators can be thought

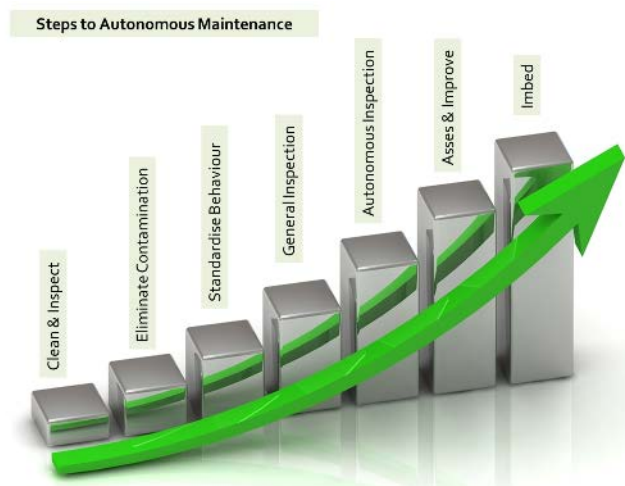
- Cleaning and greasing if applicable
- Checking wear and tear parts that are visible
- Exchanging replacement parts like computer filters
- Testing the validated state with one or more test kits

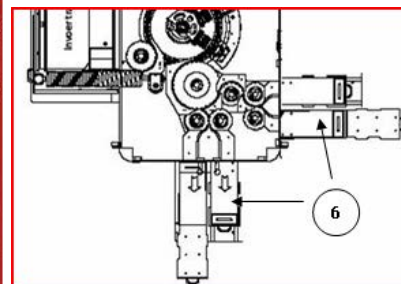
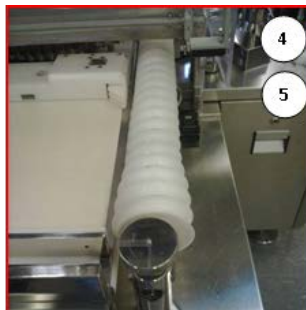
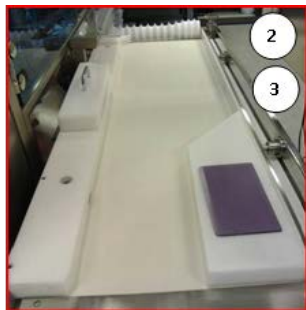
Tasks that are split in

- daily
- weekly
- monthly

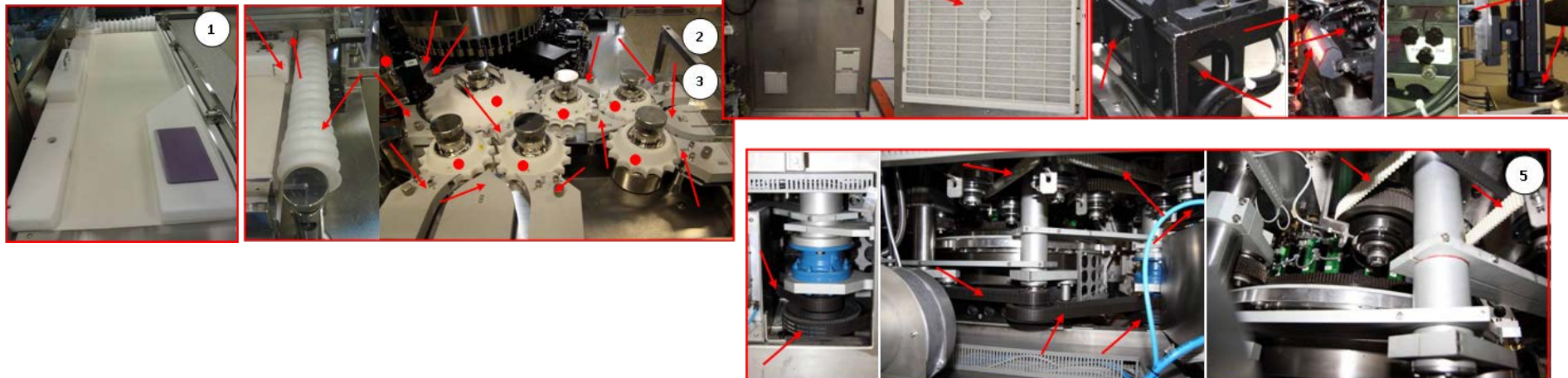
By means of

- illustrations
- checklists





Item No.	Area	Method	Criteria	Frequency				
				Per shift	daily	weekly	monthly	Time [Min]
1.	General	a. Vacuuming machine , clean with ammonia solution followed by alcohol. Plexiglas only with soap solution!! b. Line tidy and clean c. Replace vacuum cleaner bags. Combine this with a format change	<i>Free from product and dust and everything that does not functional belong</i>			+		60
2.	Intake belt	Clean with alcohol solution	<i>Free from product, dust and other dirt</i>			+		10
3.	Intake belt	Crease with silicon oil. Rub the belt with a light with silicon oil wetted cloth and rub dry afterwards.	<i>Dry and smooth. To do every two pallets</i>	+				5
4.	Intake worm	Clean with ammonia solution followed by alcohol.	<i>Free from product, dust and other dirt</i>		+	+		5
5.	Intake worm	Crease with silicon oil. Rub the worm with a light with silicon oil wetted cloth and rub dry afterwards	<i>Droog en glad. Om de twee pallets uitvoeren</i>	+				5
6.	Outlet trays	Clean with ammonia solution followed by alcohol.	<i>Free from product, dust and other dirt</i>		+			5
7.	Starwheels and guiding	Clean with ammonia solution followed by alcohol.	<i>Free from product, dust and other dirt. Formatparts may only returned in the cupboard clean!</i>		+	+		5
								15



Item No.	Area	Method	Criteria	Frequency				
				Per shift	daily	weekly	monthly	Time [Min].
1.	Intake Belt	Check on damages	No tears or fraying			+		5
2.	Starwheel and Worm	Visual inspection on damages and dirt on/in the vacuum channels	<i>No failing pieces of plastic and these channels are open</i>			+		10
3.	Guidances	Visual inspection on damages	<i>Undamaged and no missing plastic pieces</i>			+		2
4.	Lenses, mirrors, prisms	Visual inspection of the surface	No dirt, dust and scratches			+		5
5.	Drive	Visual inspection on drive belts, in doubt warn TS	<i>Drive belts have the right tension and no tears</i>			+		5
6.	Cabinet	Visual inspection on filter. 4 pieces. If necessary clean	<i>Free of dirt and dust</i>			+		5



Mastering Automated Visual Inspection

Somes References

- **Compendia**

- ✓ USP<790> visual inspection, Jan 2014
- ✓ USP<1790>, visual inspection companion chapter (guidance), Aug 2017
- ✓ Ph. Eur., JP Visual inspection

- **Articles:**

- ✓ PDA Journal all Knapp Articles from [1980-1992]
- ✓ J. Shabushnig, PDA 2014, PDA survey visual inspection;

- **Books:**

- ✓ Computer Vision: Algorithms and applications Richard Szeliski 2011
- ✓ Computer Vision: Detection, Recognition and reconstruction, Roberto Cipolla 2010
- ✓ Particle for Parenteral, J. Shabushnig, R. Cherris, PDA 2016,

- **Lectures/Webressources:**

- ✓ Stanford Univ. CA: Bernd Girod, Digital Image Processing
- ✓ Python OpenCV documenation



- Acknowledgements
 - Fernand Koert / Romain Veillon
 - PDA Europe
- PDA visual inspection committee