



## International Seminar "Road Tunnel Operations management and Safety"

18<sup>th</sup>, 19<sup>th</sup> and 20<sup>th</sup> October 2006  
Chongqing (P.R. CHINA)

### State of the art in France in equipment maintenance management

Jean-Claude MARTIN

19 Octobre 2006



1

## Foreword

In France, for a regulatory view point in order to ensure the maintenance of a tunnel equipment the operator has available :

- ↳ *General standards (on electrical equipment, maintenance, etc.)*
- ↳ *Specific documents applying most often to facilities likely to be installed in other structures than tunnels (extinguishers, fire detection systems, etc.)*
- ↳ *A technical instruction on monitoring and maintenance of tunnel (ITSEOA 79 leaflet N° 40)*

19 Octobre 2006



2

## Leaflet N° 40 : Table of contents

Initial version drafted in 1979 has been revised recently.  
The new leaflet has **four** parts :

- ↳ *Common part : civil works and equipment*
- ↳ *Boring tunnels*
- ↳ *Cut-and-covers*
- ↳ **Equipment**

19 Octobre 2006



3

- 1. Concerned Equipment**
- 2. Necessary actions**
- 3. Monitoring**
- 4. Maintenance**
- 5. Renewal**

19 Octobre 2006



4

## Concerned Equipment (1/3)

All tunnels are not equipped in the same way : generally speaking there are a few equipment in a short tunnel and there are a lot of equipment in a long or complex tunnel

In terms of maintenance the distinction is frequent between :

- ⇒ *The general facilities (essentially equipment based on mechanics and/or electro-mechanics)*
- ⇒ *The operating facilities (more sophisticated with a large use of electronics and informatics)*

19 Octobre 2006



5

## Concerned Equipment (2/3)

### General facilities

- Power supply distribution
- Lighting



19 Octobre 2006



6

## Concerned Equipment (2/3)

### General facilities

- Power supply distribution
- Lighting
- Ventilation and smoke control



19 Octobre 2006



7

## Concerned Equipment (2/3)

### General facilities

- Power supply distribution
- Lighting
- Ventilation and smoke control
- Fixed signing
- Water network for fire fighting
- Fluid removal (collection, pumping and treatment)
- Etc.



19 Octobre 2006



8

## Concerned Equipment (3/3)

### Operating facilities

- Supervisory control and data acquisition system (SCADA)
- Closed circuit television (CCTV)
- Automatic incident detection (AID)



19 Octobre 2006



9

## Concerned Equipment (3/3)

### Operating facilities

- Supervisory control and data acquisition system (SCADA)
- Closed circuit television (CCTV)
- Automatic incident detection (AID)
- Dynamic signing
- Emergency call network
- Radio-retransmission
- Etc.



19 Octobre 2006

## 1. Concerned Equipment

## 2. Necessary actions

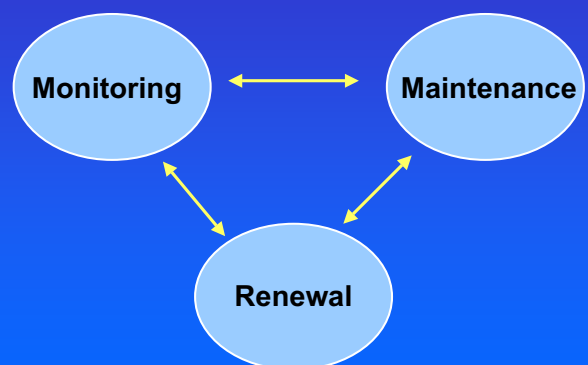
3. Monitoring
4. Maintenance
5. Renewal

19 Octobre 2006



11

## Three areas concerned



19 Octobre 2006



12

### Three areas concerned

Monitoring

✓ Continuous monitoring by SCADA for tunnels with ~~for maintenance only~~ visits systematic operations:  
→ specific controls  
→ detailed inspections



### Three areas concerned

Monitoring

Maintenance

High requirement on users' safety  
High aggressiveness of the trafficked area  
Difficult work conditions for the operating staff  
High diversity of the equipment types

### Three areas concerned

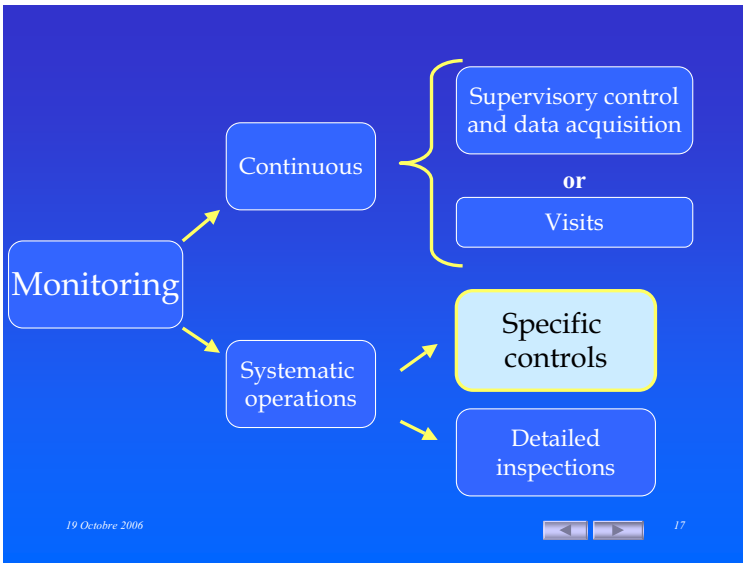
Monitoring

Maintenance

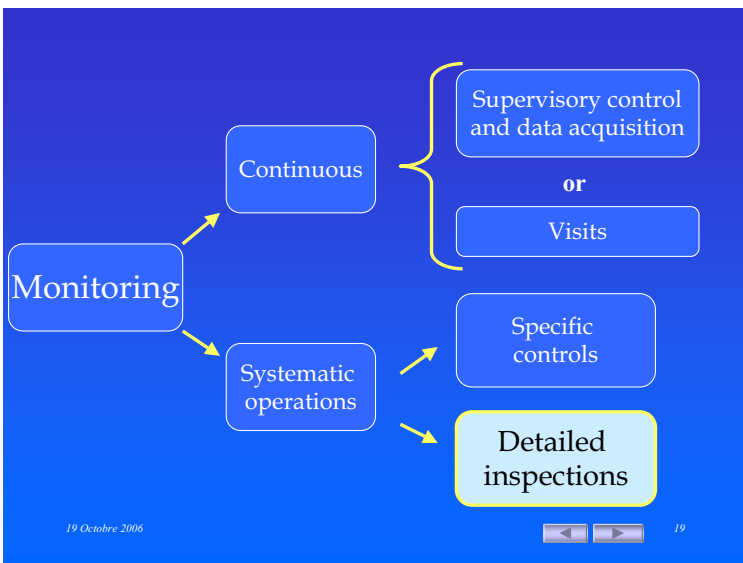
Renewal

For obsolete equipment  
In case of deterioration of performances

1. Concerned Equipment
2. Necessary actions
3. Monitoring
4. Maintenance
5. Renewal



- ### Specific controls
- Electrical facilities
  - Extinguishers
  - Lifts
  - Handling devices
  - Individual protection equipment
  - Safety lighting blocks
  - Fire detection systems
- 19 Octobre 2006 18



### Detailed inspections (1/5)

Opening of the tunnel	Initial detailed inspection (IDI)
3 <sup>th</sup> year	
6 <sup>th</sup> year	
9 <sup>th</sup> year	
12 <sup>th</sup> year	
15 <sup>th</sup> year	
18 <sup>th</sup> year	

Controls on the proper design of installations (safety viewpoint)  
 Controls on the quality of used materials and equipment (fire resistance)  
 Performance measurements  
 Functional controls  
 Individual functional sequences

19 Octobre 2006 20

## Detailed inspections

(2/5)

Opening of the tunnel	Initial detailed inspection
<b>3<sup>th</sup> year</b>	Special controls
6 <sup>th</sup> year	
9 <sup>th</sup> year	
12 <sup>th</sup> year	
15 <sup>th</sup> year	
18 <sup>th</sup> year	

Functional controls:  
 → functional sequences  
 → Safety sequences (each year)  
 → individual functioning of equipment

19 Octobre 2006

21

## Detailed inspections

(3/5)

Opening of the tunnel	Initial detailed inspection
3 <sup>th</sup> year	Special controls
<b>6<sup>th</sup> year</b>	Periodic detailed inspection
9 <sup>th</sup> year	
12 <sup>th</sup> year	
15 <sup>th</sup> year	
18 <sup>th</sup> year	

Performance measurements  
 Functional tests:  
 → per equipment functional sequences

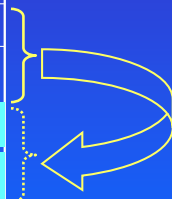
19 Octobre 2006

22

## Detailed inspections

(4/5)

Opening of the tunnel	Initial detailed inspection
3 <sup>th</sup> year	Special controls
6 <sup>th</sup> year	Periodic detailed inspection
<b>9<sup>th</sup> year</b>	Special controls
<b>12<sup>th</sup> year</b>	Periodic detailed inspection
15 <sup>th</sup> year	
18 <sup>th</sup> year	



19 Octobre 2006

23

## Detailed inspections

(5/5)

Opening of the tunnel	Initial detailed inspection
3 <sup>th</sup> year	Special controls
6 <sup>th</sup> year	Periodic detailed inspection
9 <sup>th</sup> year	Special controls
12 <sup>th</sup> year	Periodic detailed inspection
15 <sup>th</sup> year	Special controls
<b>18<sup>th</sup> year</b>	Periodic detailed inspection

Re-assessment (very close to Initial detailed inspection)

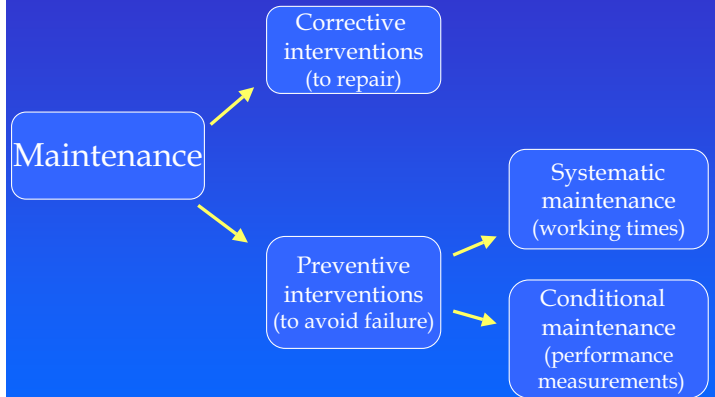
19 Octobre 2006

24

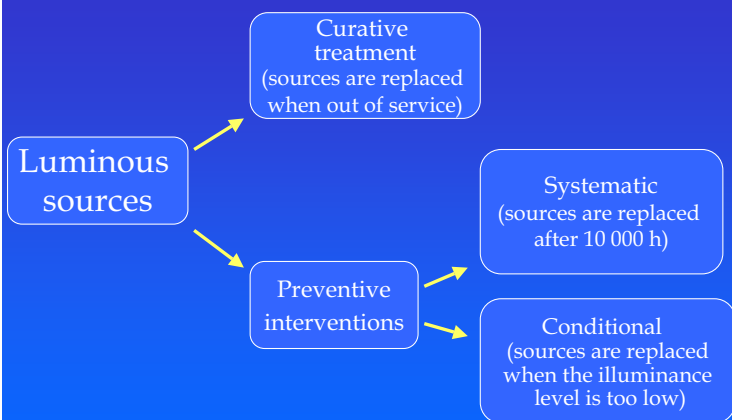
1. Concerned Equipment
2. Necessary actions
3. Monitoring
4. Maintenance
5. Renewal

Types of maintenance  
 Maintenance policy  
 Subcontracting  
 Organisation  
 Tasks to be done

### Types of maintenance



### Types of maintenance : example



1. Concerned Equipment
2. Necessary actions
3. Monitoring
4. Maintenance
5. Renewal

Types of maintenance  
 Maintenance policy  
 Subcontracting  
 Organisation  
 Tasks to be done

## Maintenance policy (1/2)

### Corrective interventions

- Non pre-planned intervention
- Time to repair could be long (to solve the problem )
- Availability of spare equipment is not sure



- Abnormal situation
- Operating restrictions (eventually closure)



Only possible for tunnel with few equipment

### Preventive interventions

- Pre -planned intervention
- Time to maintain is known
- Availability of spare equipment



Failures can not be totally eliminated but strongly reduced



Best choice in the majority of tunnels

## Maintenance policy (2/2)

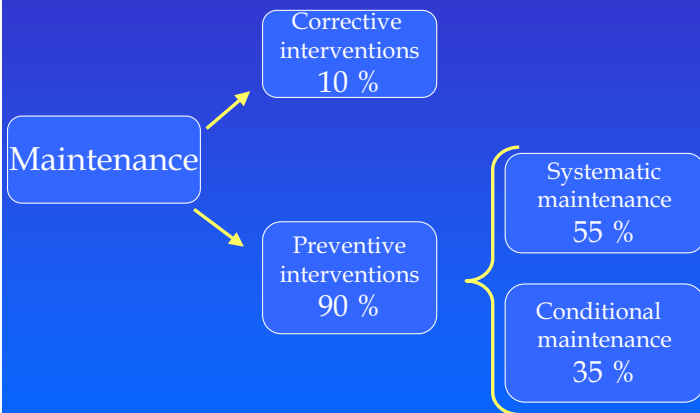
Equipment  
(type and complexity)

staff  
(competence and knowledge)



Choice for a  
maintenance policy

## Ideal distribution between maintenance type according French manufacturers



### 1. Concerned Equipment

### 2. Necessary actions

### 3. Monitoring

### 4. Maintenance

### 5. Renewal

Definitions  
Maintenance policy  
Subcontracting  
Organisation  
Tasks to be done



## Subcontracting (1/6)

The operator performs rarely all equipment tasks, most often they are handed over to subcontractors

Several choice are possible :

⇒ **Subcontracting only maintenance operations of a determined technical level**

## Subcontracting (2/6)

### Subcontracting by levels (example)

		Equipment ( non exhaustive list )					
		Power supply	lighting	ventilation	CCTV	radio	etc.
Maintenance levels (ranging from simple to complex)	1	Maintenance done by operator					
	2						
	3	Subcontractor					
	4	Subcontractor					

## Subcontracting (3/6)

The operator performs rarely all equipment tasks, most often they are handed over to subcontractors

Several choice are possible :

⇒ *Subcontracting only maintenance operations of a determined technical level*

⇒ **Subcontracting all tasks regarding one or several equipment**

## Subcontracting (4/6)

### Subcontracting per equipment family (example)

		Equipment ( non exhaustive list )					
		Power supply	lighting	ventilation	CCTV	radio	etc.
Maintenance levels (ranging from simple to complex)	1	SC	Operator			SC	SC
	2		Operator				
	3		Operator				
	4		Operator				

SC : subcontractor

## Subcontracting (5/6)

The operator performs rarely all equipment tasks, most often they are handed over to subcontractors

Several choices are possible :

- ➡ Subcontracting only maintenance operations of a determined technical level
- ➡ Subcontracting all tasks regarding one or several equipment
- ➡ **Combine the two previous approaches**

## Subcontracting (6/6)

### Combined subcontracting (example)

		Equipment ( non exhaustive list )					
		Power supply	lighting	ventilation	CCTV	radio	etc.
Maintenance levels (ranging from simple to complex)	1	Operator			SC	SC	
	2	Operator					
	3	SC	Operator	SC			
	4						

SC : subcontractor

1. Concerned Equipment
2. Necessary actions
3. Monitoring
4. Maintenance
5. Renewal

Definitions  
Maintenance policy  
Subcontracting  
➡ Organisation  
Tasks to be done

## Organisation (1/5)

Intervention conditions are dependent on :

- ➡ *Type of intervention*
  - ➔ planned (preventive)
  - ➔ non planned (corrective)
- ➡ *Intervention location*
- ➡ *Operating conditions*

## Organisation (2/5)

Intervention conditions are dependent on :

↳ *Type of intervention*

↳ *Intervention location*

↳ *Operating conditions*

→ in the tunnel  
(ceiling)  
→ in the tunnel  
(walls)  
→ in technical  
centre

19 Octobre 2006



41

## Organisation (3/5)

Intervention conditions are dependent on :

↳ *Type of intervention*

↳ *Intervention location*

↳ *Operating conditions*

→ one lane  
closure  
→ one tube  
closure  
→ tunnel  
closure

19 Octobre 2006



42

## Organisation (4/5)

The various tasks to be performed must be defined and described in a status document : the maintenance plan

Maintenance plan :

↳ *Is set up by the operator*

↳ *Then adapted regularly (feedback on experience)*

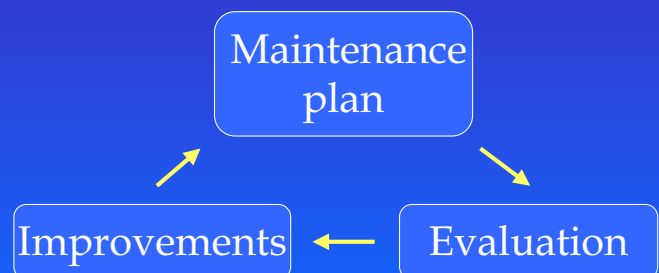
19 Octobre 2006



43

## Organisation (5/5)

Feedback on experience



19 Octobre 2006



44

1. Concerned Equipment
2. Necessary actions
3. Monitoring
4. Maintenance
5. Renewal

Types of maintenance  
 Maintenance policy  
 Subcontracting  
 Organisation  
 → Tasks to be done

## Tasks to be done (1/8)

*Tunnel facilities are gathered into 9 families to facilitate maintenance works*

- 1 : Power supply
- 2 : Lighting
- 3 : Ventilation
- 4 : Hydraulic networks (pumping and water network for fire fighting)
- 5 : Traffic signs
- 6 : Closed Circuit Television (including Automatic incident detection)
- 7 : Communication equipment to user (emergency call network, radio retransmission, etc.)
- 8 : Supervisory control and data acquisition system
- 9 : Various safety equipment

## Tasks to be done (2/8)

The preventive maintenance interventions are classified into 5 items :

⇒ *Visual controls*

- Visual control of aspect
- Control of the displayed values
- Control of supports and/or fixings
- Control of electrical connections
- Control of luminous signs readability
- Control of marking glasses visibility
- Control of lamps (out of service or not)

## Tasks to be done (3/8)

The preventive maintenance interventions are classified into 5 items :

⇒ *Visual controls*

⇒ *Cleansing*

- Sweeping technical rooms and premises the users can access to
- Dust removal from the devices (cabinets, cases, ferrules, boards, etc.)
- Washing sidewalls, traffic signs
- Internal and/or external facility cleansing

## Tasks to be done (4/8)

The preventive maintenance interventions are classified into 5 items :

⇒ *Visual controls*

⇒ *Cleansing*

⇒ *Interventions on equipment*

- Changing the filters
- Lubricating
- Tightening connections
- Adjusting amplifiers
- Changing the lamps (luminaries, road signs, etc.).

## Tasks to be done (5/8)

The preventive maintenance interventions are classified into 5 items :

⇒ *Visual controls*

⇒ *Cleansing*

⇒ *Interventions on equipment*

⇒ *Measurement of characteristics values*

- Calibration
- Checking the starting thresholds and delay times
- .Checking electrical values (voltage, power, frequency, etc.)
- Lighting and illuminance measurements
- .Air flow measurements

## Tasks to be done (6/8)

The preventive maintenance interventions are classified into 5 items :

⇒ *Visual controls*

⇒ *Cleansing*

⇒ *Interventions on equipment*

⇒ *Measurement of characteristics values*

⇒ *Functional testing*

- equipment command from the electric control panel
- Barriers closure/opening
- .Checking safeties (including emergency stopping)
- Control of safety equipment, including information transfer ( emergency exits, pulling down extinguishers, fire station valves, etc.
- Operation from the control centre

## Tasks to be done (7/8)

5 items

	Visual controls	cleansing	interventions	measurements	tests
Power supply	Tasks to be done for Power supply facilities				
Lighting	Tasks to be done for lighting facilities				
Ventilation	Tasks to be done for ventilation facilities				
Hydraulic networks	Tasks to be done for hydraulic networks facilities				
Traffic signs	Tasks to be done for traffic signs facilities				
CCTV	Tasks to be done for CCTV facilities				
Communication devices	Tasks to be done for communication facilities				
SCADA	Tasks to be done for SCADA facilities				
Various equipment	Tasks to be done for various equipment				

## Tasks to be done : example (8/8)

Plan de maintenance préventive pour le service des Trains des ouvrages d'art - 2<sup>e</sup> partie

### Power supply

Periodicités d'intervention

Code	Intitulé	Unité	Année	Trimestre	Mois	Année	Trimestre	Mois
101	Contrôle multiple	annuel						
102	Essai	annuel						
103	Essai	annuel						
104	Essai	annuel						
105	Essai	annuel						
106	Essai	annuel						
107	Essai	annuel						
108	Essai	annuel						
109	Essai	annuel						
110	Essai	annuel						
111	Essai	annuel						
112	Essai	annuel						
113	Essai	annuel						
114	Essai	annuel						
115	Essai	annuel						
116	Essai	annuel						
117	Essai	annuel						
118	Essai	annuel						
119	Essai	annuel						
120	Essai	annuel						
121	Essai	annuel						
122	Essai	annuel						
123	Essai	annuel						
124	Essai	annuel						
125	Essai	annuel						
126	Essai	annuel						
127	Essai	annuel						
128	Essai	annuel						
129	Essai	annuel						
130	Essai	annuel						
131	Essai	annuel						
132	Essai	annuel						
133	Essai	annuel						
134	Essai	annuel						
135	Essai	annuel						
136	Essai	annuel						
137	Essai	annuel						
138	Essai	annuel						
139	Essai	annuel						
140	Essai	annuel						
141	Essai	annuel						
142	Essai	annuel						
143	Essai	annuel						
144	Essai	annuel						
145	Essai	annuel						
146	Essai	annuel						
147	Essai	annuel						
148	Essai	annuel						
149	Essai	annuel						
150	Essai	annuel						

Various equipment of power supply

Actions to be done (visual controls, cleansing, etc)

Periodicity of interventions

1. Concerned Equipment
2. Necessary actions
3. Monitoring
4. Maintenance
5. Renewal

## Renewal (1/2)

The renewal of equipment can be very expensive ; so we have to anticipate this taking into account the following aspects :

- ⇒ Direct risk resulting from deterioration of the equipment for the users or operating staff
- ⇒ Breakdown of the equipment that cannot be repaired or too high breakdown frequency
- ⇒ Obsolete character of the equipment leading to impossible maintenance or repair if any breakdown occurs
- ⇒ Excessive deterioration of equipment performances

## Renewal (2/2)

Other aspects to make a renewal:

- ⇒ Service life of Equipment
- ⇒ Conditions of the Equipment
- ⇒ Performances of the Equipment

## Conclusion

In France, a new version of the leaflet on maintenance of tunnels led to define more detailed requirements in three fields :

 *monitoring*

 *maintenance*

 *renewal*

**Thank you for your attention**