

# UPDATE OF UIC LEAFLET 719 & 722 INTO IRS

719 EN



Earthworks and track bed construction  
for railway lines  
Ed. no.3 , February 2008

722 EN



Methods of improving the track formation  
of existing lines  
Ed. no.2 , October 2011

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# Summary

- 1. Main Objective**
  - 2. Meetings-Members**
  - 3. Working Groups**
  - 4. IRS Design**
  - 5. IRS Maintenance**
-

# 1. Main Objective

## **Technical and Format Update of UIC Leaflet 719**

*“Earthworks and Track bed construction for Railway Lines”*

**&**

## **UIC Leaflet 722**

*“Methods of improving the track formation of existing lines”*

**Into**

## **International Railway Solution (IRS)**

**IRS Design of Earthworks and Track Bed for Railway  
Lines**

**&**

**IRS Maintenance and Improvement of Earthworks and  
Track Bed of Existing Railway Lines**



## 2. Meetings-Members

**1<sup>st</sup> meeting – Paris – May-2016**

**2<sup>nd</sup> meeting – Madrid – September-2016**

**3<sup>rd</sup> meeting – Paris – October-2016**

**4<sup>th</sup> meeting – Madrid – March-2017**

**5<sup>th</sup> meeting – Madrid – October-2017**

**6<sup>th</sup> meeting – Madrid – March-2018**



**(Presentation of the final draft of IRS Design)**

## 2. Meetings-Members

UIC

CEDEX ●

ADIF ●

Deutsche Bahn ●

Infrabel ●

IP Engenharia ●

MÁV ●

SZDC ●

TRAFIKVERKET ●

NETWORK RAIL ○

RFI ●

SBB ●

SNCF ●

SYSTRA ●

+ China Railway Corp./CARS





# 3. Working Groups (and corresponding Work Packages)



- **WG#1: Soil classification and materials**
- **WG#2: Transition zones**
- **WG#3: Design criteria**
- **WG#4: Asphalt & bituminous layers**
- **WG#5: Soil treatment**
- **WG#6: Hydraulic sensitivity, drainage, flood risk, soil liquefaction,...**

## 4. IRS Design comes from **UIC Leaflet 719** *Earthworks and Track bed construction for Railway Lines*

### Current UIC Leaflet 719

#### Contents

##### Summary .....

##### 1 - Terminology and classification of soils and subgrades .....

###### 1.1 - Definitions .....

###### 1.1.1 - Geotechnical symbols, terms, definitions and units .....

###### 1.1.2 - Schematic cross section .....

###### 1.1.3 - Geosynthetics .....

###### 1.1.4 - Maintenance of earthworks and track bed on existing lines .....

###### 1.2 - Geotechnical classification of soils .....

###### 1.2.1 - General .....

###### 1.2.2 - Mineral soils .....

###### 1.2.3 - Organic soils .....

###### 1.2.4 - Mixture of mineral and organic soils .....

###### 1.3 - Classification of subgrades according to bearing capacity .....

###### 1.3.1 - Soil quality classes .....

###### 1.3.2 - Bearing capacity classes for subgrade .....

###### 1.4 - Frost susceptibility of soils .....

##### 2 - Earthworks and track bed for new lines .....

###### 2.1 - Geotechnical and hydrogeological studies .....

###### 2.1.1 - General .....

###### 2.1.2 - Preliminary studies .....

###### 2.1.3 - Main ground investigation .....

###### 2.1.4 - Supplementary ground investigation .....

###### 2.1.5 - Supervision of investigations .....

###### 2.1.6 - Geological and geotechnical report .....

###### 2.2 - Suitability of soil for substructure works .....

###### 2.2.1 - Body of the embankment .....

###### 2.2.2 - Prepared subgrade (embankments and cuttings) .....

###### 2.3 - Design and construction of earthworks .....

###### 2.3.1 - General .....

###### 2.3.2 - Stability analysis of earthworks .....

###### 2.3.3 - Construction of embankments and prepared subgrades .....

###### 2.3.4 - Earthworks on highly compressible or expansive soils .....

###### 2.3.5 - Transitions between structures and earthworks .....

###### 2.4 - Composition and thickness of the track bed layers to give the desired bearing capacity .....

###### 2.4.1 - Typical track bed construction .....

###### 2.4.2 - Determination of the thickness of the track bed layers to give the desired bearing capacity .....

###### 2.5 - Protection against frost .....

###### 2.5.1 - Track bed layers .....

###### 2.5.2 - Parameters for determination of required depth of frost protection .....

###### 2.5.3 - Use of frost penetration depth chart .....

###### 2.6 - Properties of materials and construction of track bed layers .....

###### 2.7 - Control of compaction .....

###### 2.8 - Drainage of subgrade .....

###### 2.8.1 - Ground water .....

###### 2.8.2 - Surface water .....

###### 2.9 - Special construction methods and materials for new lines .....

###### 2.9.1 - Treatment of soil stabilisation with binding agents .....

###### 2.9.2 - Track bed layers of limestone compacted with cement or bituminous layers .....

###### 2.9.3 - Asphalt coating .....

###### 2.9.4 - Concrete sub-ballast .....

###### 2.9.5 - Industrial by-products and recycled products .....

###### 2.10 - Ballastless track .....

###### 2.10.1 - Definition used in this paragraph .....

###### 2.10.2 - Interfaces between supporting structure and earth work .....

##### 3 - Maintenance of earthworks and track bed on existing lines .....

###### 3.1 - General maintenance .....

###### 3.2 - Maintenance of earthworks on existing lines .....

###### 3.2.1 - General remarks, inspection and day-to-day maintenance .....

###### 3.2.2 - Geotechnical and hydrogeological investigation .....

###### 3.2.3 - Inventory of remedial measures (with comments) .....

###### 3.3 - Maintenance of track bed layers .....

###### 3.3.1 - General .....

###### 3.3.2 - Determining factors .....

###### 3.3.3 - Methodology of studies for maintenance of the track bed layers and subgrade .....

###### 3.3.4 - Local repairs .....

###### 3.4 - Vegetation control .....

Chapters 1.1.4.  
and 3. will go into  
IRS Maintenance  
Contents

## 4. IRS Design New proposal for TABLE OF CONTENTS

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2. Definition of the cross section of a railway structure
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3. Classification of materials for railway structures
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  - 3.2. Materials for track bed layers or superstructure
  - 3.3. Frost susceptibility of soils (1.4)
4. Earthworks and track bed layers for new lines
  - 4.1. Geotechnical and hydrogeological studies (2.1)
  - 4.2. General (2.3.1)
  - 4.3. Earthwork: embankment
  - 4.4. Earthwork: cutting or excavation
  - 4.5. Prepared subgrade / form layer
  - 4.6. Sub-base layer / blanket layer
  - 4.7. Ballast layer (2.6)
  - 4.8. Soil treatment
5. Transition zones (2.3.5)
  - 5.1. General ideas
  - 5.2. Design
6. Ballastless track (Slab track) (2.10)
  - 6.1. General ideas
  - 6.2. Design
7. Construction requirements
  - 7.1. Earthworks and track bed layers
  - 7.2. Transition zones
  - 7.3. Ballastless track (Slab track)



## 4. IRS Design New proposal for TABLE OF CONTENTS detailed

### 1. Introduction and scope

### 2. Definition of the cross section of a railway structure

#### 2.1. Ballasted track

#### 2.2. Ballastless track (slab track)

### 3. Classification of materials for railway structures

#### 3.1. Materials for subgrade or infrastructure

##### 3.1.1. Definitions

##### 3.1.2. Classification of soils and rocks

#### 3.2. Materials for track bed layers or superstructure

##### 3.2.1. Materials for ballast layer

##### 3.2.2. Materials for subballast layer

#### 3.3. Frost susceptibility of soils (1.4)

### 4. Earthworks and track bed layers for new lines

#### 4.1. Geotechnical and hydrogeological studies (2.1)

#### 4.2. General (2.3.1)

#### 4.3. Earthwork: embankment

##### 4.3.1. Materials (2.2.1)

##### 4.3.2. Foundation (2.3.2.3. & 2.3.4)

##### 4.3.3. Stability analysis (2.3.2)

##### 4.3.4. Settlement analysis

#### 4.4. Earthwork: cutting or excavation

##### 4.4.1. Materials (2.2.1)

##### 4.4.2. Stability analysis (2.3.2)

#### 4.5. Prepared subgrade / form layer

##### 4.5.1. Thickness (1.3.2)

##### 4.5.2. Materials (2.2.2)

##### 4.5.3. Drainage (2.8)

#### 4.6. Sub-base layer / blanket layer

##### 4.6.1. Granular layers

##### 4.6.1.1. Thickness (2.4.2)

##### 4.6.1.2. Materials (2.6)

##### 4.6.1.3. Sublayers (2.4.1)

##### 4.6.1.4. Protection against frost (2.5 & 1.4)

#### 4.6.2. Asphalt or bituminous layers

#### 4.7. Ballast layer (2.6)

#### 4.8. Soil treatment

##### 4.8.1. Materials to be treated

##### 4.8.2. Methods of treatment

##### 4.8.3. Treated material properties

##### 4.8.4. Use of treated material

### 5. Transition zones (2.3.5)

#### 5.1. General ideas

#### 5.2. Design

### 6. Ballastless track (Slab track) (2.10)

#### 6.1. General ideas

##### 6.1.1. Definition

##### 6.1.2. Slab track analysis

##### 6.1.3. Slab track cross section

##### 6.1.4. Transition zones

#### 6.2. Design

##### 6.2.1. Slab track System Requirements

##### 6.2.2. Railway traffic loads

##### 6.2.3. Substructure

##### 6.2.4. Environmental conditions

### 7. Construction requirements

#### 7.1. Earthworks and track bed layers

##### 7.1.1. Construction of embankments and prepared subgrades (2.3.3)

##### 7.1.2. Control of compaction (2.7)

##### 7.1.3. Special construction methods and materials for new lines (2.9)

#### 7.2. Transition zones

#### 7.3. Ballastless track (Slab track)

## 4. IRS Design

1. Introduction and scope
2. Definition of the cross section of a railway structure

### 2.1 Ballasted track

### 2.2 Slab track (Ballastless track)

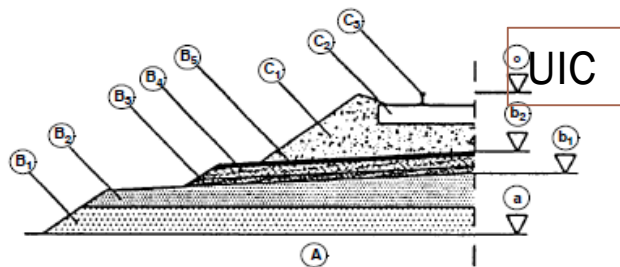
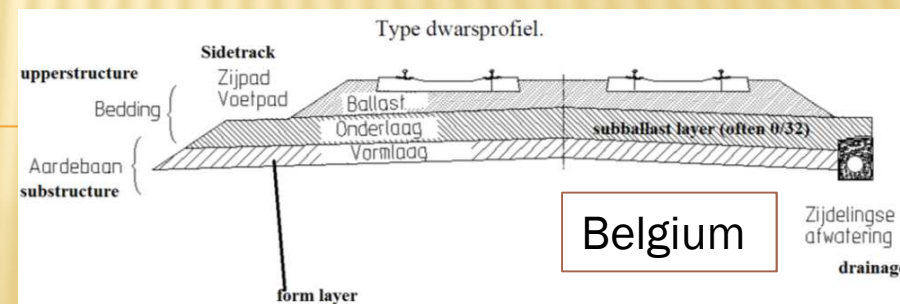


Fig. 31 - Schematic cross-section

Table 2 : Terms and examples

	Layers		Surfaces		Examples of materials used
Super-structure	C3	Rail surface	c	Running	(rail top) - Rail steel
	C2	Sleeper			- Timber - Steel - Concrete
	C1	Ballast			- Crushed hard stone
Infra-structure	B5	Sub-ballast layer	b2	Blanket layer	- Bitumen cover - Mineral aggregate
	B4	Foundation layer			- Sandy gravel I, II, 100, 120 - Sandy gravel CFF
	B3	Filter layer			- Sand - Geotextile
	B2	Prepared subgrade	b1	Prepared subgrade	- Compacted - Replacement fill - Stabilisation
	B1	Embankment			
	A	Natural subgrade	a	Surface of natural subgrade	

- Definition of railway track section
- Superstructure/understructure
- Track bed layer:  
Ballast+Subballast





## 4. IRS Design

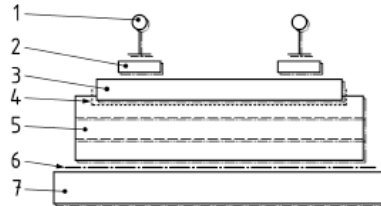
1. Introduction and scope
2. Definition of the cross section of a railway structure

### 2.1 Ballasted track

### 2.2 Slab track (Ballastless track)

#### 5.1 Ballastless track system, subsystems and components

A ballastless track system may consist of (but is not limited to) following levels of subsystems and components shown in Figure 1.



Key	Item	Type
1	Rail/switch and crossing	Subsystem
2	Fastening system /system for embedded rail	Subsystem
-	Clip, clamp, rail pad etc.	Component
-	Adhesive	Component
3	Prefabricated element	Subsystem
-	Sleeper, block	Component
-	Slab, frame	Component
4	Intermediate layer, boot, fixation	Subsystem
-	Concrete filling layer	Component
5	Pavement	Subsystem
-	Single-, multi-layered pavement	Component
-	Base layer	Component
6	Intermediate layer	Subsystem
-	Foil, sheeting	Component
-	Compensation layer	Component
7	Substructure	System

Figure 1 — Ballastless track system - subsystems and components

- ✓ Use of Slab Track section from

### EN 16432-2:

Railway applications - Ballastless track systems - Part 2: System design, subsystems and components

- ✓ Include “angular distortion” and “settlements” as slab track design criteria.

## 4. IRS Design

### 3. Classification of materials for railway structures

#### 3.1 Materials for subgrade or infrastructure

##### 3.1.1 Definitions

##### 3.1.2 **Classification of soils** and rocks



## PRINCIPLES

- ✓ Concepts for UIC Materials groups (QSi) are kept
- ✓ Classification according to EN 16907-2 “Earthworks. Classification of materials”
- ✓ Classification based on test results



## 4. IRS Design

### 3. Classification of materials for railway structures

#### 3.1 Materials for subgrade or infrastructure

##### 3.1.1 Definitions

##### 3.1.2 **Classification of soils** and rocks

✓ According to EN 16907 “Earthworks”

✓ By Tests:

Particle size distribution  
Plasticity  
Organic Material Content test  
Soluble Sulphate Content test  
Soluble Salt Content test  
Proctor test  
CBR  
Swelling test  
Collapse test

Parameter	QS0 Unsuitable material	QS1 Poor material	QS2 Average material	QS3 Good material
Geotechnical classification (Soil group symbol according to Tables 3a-3e)	CIV – CIE MOSa – MOSi MOCi – PE	ISL – ISH SIL – CIL SIM – CIM CIH – LOSa LOSi – LOCi	GrN – SaN CGrW – CGrN CSaW – CSaN	GrW-SaW
Organic material content (%)	>6	<6	<2	<1
Sulphate content (SO <sub>3</sub> %) (Tabla 4d pr 16907)	>10	<10	<1	<0.1
Soluble salt content(%)	>1	<1	<0.5	<0.2
CBR	<3	>3	>5	>17
Free swelling (%)	>3.0	<3.0	<2.0	<1.0
Collapse (%)	>2.0	<2.0	<1.0	<0.5

Classification  
of Soils

## 4. IRS Design

Parameter	QS1 Poor material	QS2 Average material	QS3 Good material
Fragmentability (NF P 94-66)	$FR \geq 7 \%$	$FR < 7 \%$	$FR < 7 \%$
Degradability UNE 146510	$DR > 2\%$ * $DR > 20\%$	$DR \geq 2\%$ $5 \leq DR \leq 20\%$	$DR < 2\%$ $DR < 5\%$
Micro Deval (EN 1097-1)	$MD > 40$	$25 < MD \leq 40$	$MD \leq 25$
Los Angeles Index test (EN 1097-2)	$LA > 40$	$30 < LA \leq 40$	$LA \leq 30$
Slake Durability Test		$> 70\%$ (ADIF)	
Soluble Sulphate Content (%)			$< 1\%$
Soluble Salt Content (%)			
Organic Material content (%)			$< 2\%$
Density (EN 1097-6)	$< 1,7 \text{ t/m}^3$	$\geq 1,7 \text{ t/m}^3$	$\geq 1,7 \text{ t/m}^3$
Uniaxial Compression Strength	$< 5 \text{ MPa}$	$5-50 \text{ MPa}$	$> 50 \text{ MPa}$

✓ According to EN 16907  
“Earthworks”

✓ By Tests:

Particle requirements

Fragmentability (NF P 94-66)  
Degradability (UNE  
146510≈ASTM D 4644, and  
NF P 94-67)

Micro Deval (EN 1097-1)  
Los Angeles Index (LA) (EN  
1097-2)

Slake Durability Test (¿?)

Chemistry requirements

Soluble Sulphate Content  
test

Soluble Salt Content test

Organic Material Content test

Strength requirements

Density (EN 1097-6)

Uniaxial compression test

**Classification of Rocks  
for filling purposes**



## 4. IRS Design

✓ According to EN 16907 “Earthworks”

### 3. Classification of materials for railway structures

#### 3.1 Materials for subgrade or infrastructure

##### 3.1.1 Definitions

##### 3.1.2 **Classification** of soils and **rocks**



✓ By Tests:

Chemistry requirements

Soluble Sulphate Content test

Soluble Salt Content test

Organic Material Content test

Strength requirements

Density (EN 1097-6)

Uniaxial compression test

Deformation modulus in static plate test (Ev2)

Parameter	QS0 Unsuitable material	QS1 Poor material	QS2 Average material	QS3 Good material
Soluble Sulphate Content (%)	--	--	--	<1%
Soluble Salt Content (%)				
Organic Material content (%)	--	--	--	<2%
Density (EN 1097-6) ( $\rho$ )	--	<1,7 t/m <sup>3</sup>	≥1,7 t/m <sup>3</sup>	≥1,7 t/m <sup>3</sup>
Uniaxial Compression Strength	--	< 5 MPa	5-50 MPa	>50MPa
Deformation modulus in static plate test (Ev <sub>2</sub> - MPa)	<12,5	12,5<Ev <sub>2</sub> <25	25< Ev <sub>2</sub> <80	Ev <sub>2</sub> >80

**Classification of Rocks as railway structure support**

## 4. IRS Design

### 4. Earthworks and track bed layers for new lines

#### PRINCIPLES BASED ON

- ✓ Material coming from current UIC 719
- ✓ Ideas coming from EN 16907
  - ✓ Part 3 “Construction procedures”
  - ✓ Part 4 “Soil treatment with ...”
  - ✓ Part 5 “Quality control”

EUROPEAN STANDARD	<b>FINAL DRAFT</b>
NORME EUROPÉENNE	<b>FprEN 16907-3</b>
EUROPÄISCHE NORM	
February 2018	
ICS 93.020	
English Version	
Earthworks - Part 3: Construction procedures	

EUROPEAN STANDARD	<b>FINAL DRAFT</b>
NORME EUROPÉENNE	<b>FprEN 16907-4</b>
EUROPÄISCHE NORM	
February 2018	
ICS 93.020	
English Version	
Earthworks - Part 4: Soil treatment with lime and/or hydraulic binders	

EUROPEAN STANDARD	<b>FINAL DRAFT</b>
NORME EUROPÉENNE	<b>FprEN 16907-5</b>
EUROPÄISCHE NORM	
February 2018	
ICS 93.020	
English Version	
Earthworks - Part 5: Quality control	



## 4. IRS Design

### 5. Transition zones



- ✓ Mainly material coming from current UIC 719
- ✓ No great changes


### 6. Ballastless track (Slab track)



- ✓ Material coming from current UIC 719
- ✓ Some ideas coming from EN 16432-2: Railway applications - Ballastless track systems - Part 2: System design, subsystems and components

## 4. IRS Design

### 7. Construction requirements



## PRINCIPLES BASED ON

- ✓ Material coming from current UIC 719
- ✓ Ideas coming from EN 16907
  - ✓ Part 3 “Construction procedures”
  - ✓ Part 5 “Quality control”

EUROPEAN STANDARD NORME EUROPÉENNE EUROPÄISCHE NORM	<b>FINAL DRAFT FprEN 16907-3</b>
February 2018	
ICS 93.020	
English Version	
Earthworks - Part 3: Construction procedures	

EUROPEAN STANDARD NORME EUROPÉENNE EUROPÄISCHE NORM	<b>FINAL DRAFT FprEN 16907-5</b>
February 2018	
ICS 93.020	
English Version	
Earthworks - Part 5: Quality control	

## 5. IRS Maintenance and Improvement of Earthworks and Track Bed of Existing Railway Lines comes from **UIC Leaflet 722**

(Methods of improving the track formation of existing lines)

### UIC Leaflet 722

#### Summary .....

#### 1 - Civil engineering methods of improving the formation .....

- 1.1 - Formation Improvement (FI) by means of a formation protective layer (PL) of mineral substances (formation sand and gravel) .....
- 1.2 - Formation improvement with formation sand and gravel (FSG) and geotextiles .....
- 1.3 - Formation improvement by laying treated materials.....
- 1.4 - Creation of frost-resistance by laying of thermal insulation sheets.....

#### 2 - Description of methods .....

- 2.1 - Formation Improvement with formation sand and gravel (FSG).....
- 2.2 - Formation improvement with FSG and geotextiles.....
- 2.3 - Formation improvement by laying of treated materials.....
- 2.4 - Laying of thermal insulation sheets .....

#### 3 - Evaluation of the working methods .....


- 3.1 - Operating conditions.....
- 3.2 - Civil engineering conditions .....
- 3.3 - Staffing and machine costs for 100 m formation improvement.....
- 3.4 - Performance for each working method.....
- 3.5 - Evaluation of quality of work .....

#### 3 - Maintenance of earthworks and track bed on existing lines .....

- 3.1 - General maintenance .....
- 3.2 - Maintenance of earthworks on existing lines .....
- 3.2.1 - General remarks, inspection and day-to-day maintenance ...
- 3.2.2 - Geotechnical and hydrogeological investigation .....
- 3.2.3 - Inventory of remedial measures (with comments) .....

#### 3.3 - Maintenance of track bed layers.....

- 3.3.1 - General .....
- 3.3.2 - Determining factors .....
- 3.3.3 - Methodology of studies for maintenance of the track bed layers and subgrade .....
- 3.3.4 - Local repairs .....
- 3.4 - Vegetation control.....



UIC 719 Chapters 1.1.4.  
and 3. are included in  
this new IRS



## **4. IRS Maintenance Proposal for New TABLE OF CONTENTS**

### **1. Introduction and scope**

### **2. Problems to be detected**

- 2.1 Cuttings
- 2.2 Embankments
- 2.3 Platform
- 2.4 Drainage works
- 2.5 Slab track

### **3. Methodology of studies**

- 3.1 Phase 1: Desk studies
  - 3.1.1 Geological – geotechnical analysis
  - 3.1.2 Hydrological analysis
  - 3.1.3 Previous site technical documentation
- 3.2 Phase 2: Routinary in-situ inspections
- 3.3 Phase 3: Special/detailed in-situ inspections
- 3.4 Phase 4: Risk and priority order analysis
- 3.5 Phase 5: Analysis of alternative solutions
- 3.6 Phase 6: Design of solution
- 3.7 Phase 7: Implementation of solution

### **4. Remedial measures**

- 4.1 Cuttings
- 4.2 Embankments
- 4.3 Platform
- 4.4 Drainage works
- 4.5 Slab track

### **5. Methods of improving the track formation of existing lines (UIC-722)**

# UPDATE OF UIC LEAFLET 719 & 722 INTO IRS

719 EN



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for railway lines  
Ed. no.3 , February 2008

722 EN



Methods of improving the track formation  
of existing lines  
Ed. no.2 , October 2011

Dr. José Estaire (*Head of CEDEX Track Box – CEDEX*)  
David Villalmanzo (*Infra Senior Advisor Rail System Dept. – UIC*)