

# ORGANISATION OF THE WORK FOR WINTER ROADS MAINTENANCE IN THE SPANISH NATIONAL ROAD SYSTEM

M<sup>a</sup>. R. Cornejo Arribas  
Ministry of Development. Subdirector-General for Maintenance and Operation  
[rcornejo@fomento.es](mailto:rcornejo@fomento.es)

A. Sánchez  
Ministry of Development-Directorate General of Roads, Madrid, Spain  
[asvicente@fomento.es](mailto:asvicente@fomento.es)

L. Azcue  
Ministry of Development-Directorate General of Roads, Madrid, Spain  
[lazcue@fomento.es](mailto:lazcue@fomento.es)

## SUMMARY

The Directorate General of Roads winter road maintenance activities are carried out by the companies that have been awarded the Integral Conservation Contracts. These companies provide the human and material resources set forth in the Specifications Sheet that was used for awarding the Contract, based on the dimensions of the Service Level assigned to the roads in the sector.

The resources used are controlled through Operating Plans that include the action procedures and system for executing the work that is to be done. Participation of the different State Administration bodies intervening in the winter road maintenance operations is regulated through the coordination protocols.

The challenge faced by the Authorities in achieving improvements in road traffic conditions in the winter is to promote the implantation of new technologies and, as has been deduced from more recent experience, to improve coordination between the agents intervening in matters having to do with establishing traffic restrictions, for the purpose of improving traffic control in these situations, particularly in high density urban areas.

## KEY WORDS

**CLIMATE / NATIONAL ROAD NETWORK / COORDINATION PROTOCOLS / SERVICE LEVELS / OPERATING PLANS / EMERGENCY PARKING FACILITIES**

## 1. THE NATIONAL ROAD NETWORK.

The country of Spain is located in the Iberian peninsula, in southern Europe. It has an extension of 505.954 sq km. Its population in 2008 amounted to 45.3 million inhabitants, representing a density of 89 inhabitants per sq km.

The Spanish relief is based on a large central massif that occupies practically 50% of the country of a considerable height. This means that Spain is the second highest country in Europe in terms of average altitude (660 m.) This massif is encircled by a series of mountainous crests, with the exception of the western side.

Spain enjoys a temperate climate, with moderate temperatures, little rainfall, mild winters and dry summers, which gives it an apparently unified climate, due to the existence of marked contrasts in temperatures and rainfall from one region to another. This means that technically speaking, nine main peninsular climatic regions can be established: two regions where there are harsh winters (with the average temperatures ranging from less than -3°C during the coldest month to over 10 °C in milder months), a region with a desert climate (with an evaporation rate that is higher than the rainfall and a dry winter season), four regions with wet, temperate climates (in which the coldest month has an average temperature of between 18 and -3°C) and two regions with dry climates (with evaporation rates that are higher than the rainfall and average annual temperature above or below 18°C). The factors that determine the temperature in the peninsula are fundamentally the rugged relieve and the important water masses that surround it, and the latitude which results in a large number of hours of sunshine.

In the winter, there are regions with many days of ice and snow. Some areas have from 40 to 50 days of snow every year and are surrounded by extensive areas with between 20 and 40 days of snow. With respect to the number of days on which ice forms, the highest areas have between 150 and 250 days of ice per year, although in the majority of the country, there are between 100 and 50 days of ice every year.

We can therefore say that in the winter, practically half of Spanish territory is affected by problems of ice and snow, meaning that it is necessary to carry out winter maintenance work on some 10,400 km. of roads in the National System.

The country is comprised of seventeen autonomous regions, each of which is organised in a similar way to a federal state. They all have a high degree of autonomy and their own legislative, budgetary, administrative and executive authority which is guaranteed by the state through the respective Statutes of Autonomy. Each community or region is divided up into one or several provinces, making a total of fifty-two.

In administrative terms, the Spanish national road system is organised through three different Authorities: the National Roads System which reports to the Ministry of Development, the Regional Communities Systems and the Provincial and Insular Systems.

The National Roads System (RCE) includes all national roads that form long-distance routes and link up the different regions. The regional community systems are regional in scope and the provincial and insular systems are local in scope. This local network is completed by the municipal system, which is controlled by the municipal authorities.

The length of the National Road System compared to the total length of the Spanish Road System (RE) is as follows:

	<i>National Road System (RCE)</i>	<i>Spanish Road System (RE)</i>	<i>(RCE)/(RE) %</i>
Motorways and Dual Carriageways	10,634 km. (40.8 %)	13,873 km. (8.3 %)	76.6
Conventional Roads	15,407 km. (59.2 %)	152,467 km. (91.7 %)	10.1
TOTAL	26,041 km.	166,340 km.	15.6

As regards the traffic driving along the Spanish road system, it is distributed as follows:

<i>Light traffic distribution – (% heavy traffic)</i>	
National Road System (RCE)	51.9 % - (17.0 %)
Regional System	41.8 % - (9.5 %)
Provincial and Insular System	6.3 % - (10.3 %)

The Directorate General of Roads of the Ministry of Development has entrusted the technical and operating management of the road infrastructure forming the National Road System. Its functions include the maintenance of the roads during the winter season in the roads falling within the applicable scope.

The work involved in winter maintenance was formerly carried out by the peripheral services of the Directorate General of Roads, i.e., with staff and resources from the Administration. However during the past twenty years, maintenance has been contracted with private companies through integral maintenance contracts. These contracts include the ordinary maintenance and work in maintaining the roads, which therefore includes all work related to winter road maintenance. The company awarded the contract is responsible for executing the work and for making available the human and material resources and the Administration directs, checks, coordinates and guarantees its correct execution. The maximum length of the contracts is 4 years and they may be extended for another 2 years.

These integral maintenance contracts have the necessary human resources to execute the work and technical staff dedicated to the management, planning and monitoring of the contract, which is managed by an Engineer who represents the company and is responsible for ensuring the correct execution of the work. He is the person with maximum authority for complying with the Winter Maintenance Operating Plan in the roads in the sector, and the Administration is responsible, among other things, for ensuring that the Operating Plan is fulfilled and ordering the necessary measures to be taken to achieve the purposes established therein. Winter maintenance is ensured using permanent brigades who are paid on a monthly basis during the winter maintenance season, including their availability and functioning. The fluxes used are paid based on unit prices.

The National Road System is divided up into 168 sectors, with an average length of 70 km. for dual carriageways and 150 km. for conventional roads. Maintenance in practically all the sectors is carried out through these integral maintenance contracts.

Through the system implanted, the entire winter maintenance season in most sectors lasts for six months, from 1 November to 30 April, and is based on a stable structure with the appropriate resources, and the necessary knowledge of how the work to be carried out must be executed to maintain the National system roads in the best possible conditions of use and security during the winter months.

The important increase in traffic volumes, the constant putting into service of new motorway sections and the greater demands made by users has led to the resources available in the different sectors being considerably increased during recent years, in order to achieve the service levels established, with the number of snow ploughs being multiplied by 4 and the storage capacity of fluxes being increased 6.5-fold.

<i>SEASON</i>	<i>Push snow ploughs (%increase)</i>	<i>Fluxes storage capacity(T.) (%increase)</i>
1996/1997	257	26,648
97/98	291 (+13%)	30,898 (+16%)
98/99	388 (+33%)	36,435 (+18%)
1999/2000	409 (+6%)	38,737 (+6%)
2000/01	445 (+9%)	39,610 (+2%)
01/02	450 (+1%)	44,942 (+13%)
02/03	486 (+8%)	50,308 (+12%)
03/04	561 (+15%)	57,221 (+14%)
04/05	609 (+9%)	60,171 (+5%)
05/06	795 (+31%)	133,534 (+122%)
06/07	827 (+4%)	137,583 (+3%)
07/08	994 (+20%)	178,004 (+29%)
08/09	1,036 (+4%)	178,085 (+0.1%)

The resources assigned for the 2008/2009 winter road maintenance work on National System roads were as follows:

- o 1,036 push snow ploughs
- o 35 dynamic snow ploughs
- o 308 fluxes storage
- o 374 fluxed silos
- o 178,085 T of fluxes

Total consumption of fluxes during the last season 2008/2009, amounted to 385,000 (420,000 including toll roads) tons of common salt (ClNa), and 77,000,000 (87,000,000 including toll roads) litres of liquid brine, as opposed to the average consumption of 160,000 T. of ClNa, due to the particularly hard winter conditions in 2008/2009.

The total cost of this season 2008/2009 is estimated at around 64.71 million euros, of which approximately 34.71 million would correspond to snow ploughs, 10.5 million to personnel expenses, 18.2 million to fluxes and 1.3 million to liquid brine.

The territorial distribution of the push snow ploughs and dynamic snow ploughs is as follows:

<b>SEASON 2008/2009</b>		
<i>REGION</i>	<i>Push snow ploughs</i>	<i>Dynamic snow ploughs</i>
Andalucía Occidental	9	0
Andalucía Oriental	27	0
Aragón	128	4
Asturias	33	2
Cantabria	45	8
Castilla La Mancha	150	0
Castilla y León Occidental	142	4
Castilla y León Oriental	154	8
Cataluña	86	6
Extremadura	25	0
Galicia	72	0
Madrid	93	3
Murcia	9	0
La Rioja	19	0
Valencia	44	0

The territorial distribution of the storage capacity and consumption of fluxes is the following:

<b>SEASON 2008/2009</b>			
<i>REGION</i>	<i>Storage Capacity (T.)</i>	<i>Consumption of ClNa (T.)</i>	<i>Consumption of Liquid Brine (litres)</i>
Andalucía Occidental	1,225	153,258	0
Andalucía Oriental	2,971	4,466,480	493,339
Aragón	19,213	25,075,700	7,885,400
Asturias	3,120	7,721,410	545,751
Cantabria	12,610	8,356,240	1690,460
Castilla La Mancha	34,927	51,200,600	15,389,400
Castilla y León Occidental	23,980	78,058,300	13,838,800
Castilla y León Oriental	26,595	83,929,900	13,946,500
Cataluña	13,252	15,659,900	3,700,020
Extremadura	1,767	1,019,670	1,307,600
Galicia	14,510	61,183,900	3,432,300
Madrid	13,255	36,196,700	9,744,850
Murcia	2,500	539,500	320,750
La Rioja	4,180	7,763,350	425,526
Valencia	3,980	3,465,330	4,333,400

The activities carried out for winter road maintenance on the National System roads are implemented based on the Service Note of October 2006, issued by the General Directorate of Roads Sub-directorate General of Maintenance and Operation, concerning the activities of the Maintenance Services in winter road maintenance.

## **2. COORDINATION PROTOCOLS**

These activities are included in the Provincial Protocols, implemented through the Coordination Protocol of the General State Administration Institutions in the event of heavy snowfalls and other extreme weather conditions, agreed with those responsible from the General Civil Protection and Emergency Directorate, Traffic, Roads, Defence Policy, Road Transport Directorates and the National Weather Agency (this protocol was updated in March 2009), and also in the Winter Road Operating Plans of each sector in the System.

That Protocol is intended to strengthen the coordination systems between the different State Administration bodies, with a view to guaranteeing safe road conditions on the System roads in the event of snowfalls and other extreme weather conditions, all with the objective of preventing or reducing to a minimum the number of sections with traffic hold-ups and the length of these hold-ups, and to guarantee attention to the people inside the vehicles. This Protocol establishes the obligation to draft provincial protocols for which purpose a series of criteria are set, in addition to the special provisions that must be made in them, for roads entering large cities.

The protocols contain a list of the state bodies that have participated in drafting them, the authority assigned to each one and the operating procedures for each of the phases of development of the situation (alert phase, pre-emergency phase and emergency phase). Furthermore, the possibility of participation by the Military Emergency is contemplated, if the situation so requires.

### 3. SERVICE LEVELS

The strategies in executing the winter road maintenance work are set forth in the documents entitled Winter Maintenance OPERATING PLANS, drafted for each sector, which include potential situations that may arise and the necessary staff and technical resources to tackle each one, with the desirable purpose of reducing the number of perturbations to traffic to the minimum that is assigned along each section of the sector roads, depending on the SERVICE LEVEL that is established. This Service Level, which is established based on the Service Note of October 2006, is taken as the degree of transitivity that a certain section of the road must have during the winter season, irrespective of the climate in the region, and is based exclusively on functional criteria.

For each of the 3 service levels established a maximum number of perturbations that can occur as a result of snow and ice is set, and the maximum length of these perturbations.

The perturbations and alternations considered are: "*hold-ups in the movement of heavy traffic*", understood as a measure that is aimed at preventing these vehicles from straddling the road; "*driving of light vehicles with chains*", which is intended to increase the traction of vehicles in conditions of poor adherence to the road surface due to the presence of snow or ice; "*total stoppage of road traffic*" when there no vehicles are yet straddling the road but the enormous quantity of snow makes it impossible for any vehicles to move; and lastly "*blocking of the road*" which is a situation in which no traffic can move, due to the presence of vehicles on the road, usually heavy vehicles straddling the road and queues of trapped light vehicles.

Service Level 1 is the most demanding with respect to winter maintenance, and the one with the best effects in terms of transitivity along the section of road where it is implanted. In the road sections where this service level is assigned, the objective is to ensure that the road is permanently in normal conditions, with no situations of blockage or hold-ups in traffic of all vehicles as a result of snow, in any circumstances. To reach this service level, permanent surveillance must be maintained and the constant provision of winter maintenance work. In conditions of snow, the measure of prohibiting the movement of heavy vehicles and ensuring that light vehicles have chains is applied whenever necessary, in an attempt to reduce the restriction time as much as possible. Once the cause (snowstorm) has ended, a maximum period of two hours is established during which to restore the traffic to normal driving conditions.

On sections of road to which Service Level 2 is assigned, every effort is made to ensure normal road conditions at all times, and alterations in the traffic due to snowfalls are admitted in the case of important episodes. At most, a blocked road situation is admitted, with traffic hold-ups affecting all vehicles. Logically, a longer time is established for restoring the traffic to normal conditions once the storm has ended; four hours. For this level, preventive and curative treatment is applied continuously during the winter season, when considered necessary, and permanent surveillance services are provided only when there is news of adverse weather conditions.

Service Level 3 is the least demanding of all. As a general rule, this level is assigned to sections of road of little importance in the System as a whole. In this case, the roads are maintained, but alterations are allowed in normal traffic conditions due to snowfalls provided that the intensity of the storm makes it necessary to move staff to meet the requirements of roads assigned a higher service level. Consequently, the service is provided on a discontinuous basis depending on the need to act in nearby areas at a higher level. For this level, no limits are established as regards blocking the road or

interrupting traffic, and no maximum times are set for restoring the normal driving conditions.

### SERVICE LEVELS

Maximum number of perturbations caused to traffic due to snow and ice and maximum times in each case. (Desirable objectives)

NS	Phenomenon	Interrupt of heavy traffic		Chains Light Vehicles		Total Blockage		Blockage	
		Number	Time	Number	Time	Number	Time	Number	Time
NS-1	SNOW	Indeter.	t+2 h	Indeter.	t+2 h	0		0	
	ICE	0		0		0		0	
NS-2	SNOW	Indeter.	t+4 h	Indeter.	t+4 h	Once	t+4 h	once	t+4 h
	ICE	0		0		0		0	
NS-3	SNOW	Indeter.	-	Indeter.	-	Indeter.	-	Indeter.	-
	ICE	0		0		0		0	

(Indeter. = Indeterminate number of times) (t+XH= time the storm lasts plus x hours)

For the purpose of clearing the sides of the road in general, a series of maximum times are established from the time the storm ends, ranging from 6 hours for Service Level 1 to one day for Service Level 2. No time limit is established for Service Level 3 with respect to clearing the roads.

An important fact of the 2006 service note is that no traffic perturbations or alterations that are caused by the presence of ice are permitted for any of the service levels considered.

Logically, all these values are taken as desirable values and are therefore useful when it comes to dimensioning the resources and establishing the work systems of the Operating Plans.

The assigning of SERVICE LEVELS to each road is done applying the following criteria:

Service Level 1 (NS-1):

- All Motorways and Dual Carriageways
- Conventional roads with  $ADI \geq 5,000$ , except for mountains passes with alternative routes along motorways or dual carriageways which are assigned the NS-2 level
- Roads leading to the most important ski resorts
- All provincial capitals with populations of more than 20,000 inhabitants through which a National System road passes will be linked to the main system, which for this purpose is the one assigned Service Level 1, by at least one Service Level 1 road
- For both this level and for Service Level 2, every attempt will be made to assign the same level to all the road sections included in the same route, to guarantee uniformity between the place of origin and the place of destination.

Service Level 2 (NS-2):

- Conventional roads with  $1,000 \leq ADI < 5,000$
- All other roads leading to provincial capitals and cities with populations of more than 20,000 will be assigned at least Service Level 2.
- All towns with more than 4,000 inhabitants through a National System road passes will be linked to the main system or Secondary System, for that purpose, one that is assigned Service Level 2, by at least one Service Level 2 road.

Service Level 3 (NS-3):

- All other conventional roads, except for mountain passes located between two provinces or which are the only routes that link up to towns with more than 2,000 inhabitants.

#### **4. OPERATING PLANS**

As indicated above, the strategies to be adopted and the systems of the operations to be implemented in executing the work involved in winter road maintenance are defined in what are known as the Winter Maintenance OPERATING PLANS.

The Operating Plans of each sector include the following information, at least:

- Staff and machines assigned to the Sector, with an indication of the snow trucks, snow ploughs, dynamic snow ploughs, land-rovers, diggers, flux-spreading machines, anti-sleet screens, etc.
- Silos and tanks in the Sector and the vicinity thereof, with an indication of their storage capacity, location, entrances, etc.
- Plants that manufacture liquid brine, production capacity, location, manufacturing capacity, etc.
- Communication systems between the bases and vehicles and weather report transmission channels, traffic alterations and alterations of all types. This includes the organisation that is established for sending reports in real time on traffic perturbations or any other incidents.
- Organisation of preventive work involving the spreading of fluxes, indicating the routes established for each situation being studied, resources to be used, surveillance and inspection routes, work execution calendar, etc.
- Organisation of preventive work in spreading the fluxes and removing the snow, indicating the distribution of equipment for each situations being studied, the routes assigned, alternative routes, especially difficult sections, procedures for establishing traffic restrictions, etc.
- Auxiliary systems for controlling the winter maintenance resources in the sector, such as weather stations, satellite location systems (GPS), automatic flux sprinklers, etc.

Based on the weather information received, and once the weather conditions are known, and the zone that may be affected, the Winter Maintenance Operating Plan considers the different situations that could arise and organises the work of the respective staff in applying the preventive and curative treatments.

The fluxes used in these applications are Sodium Chloride (ClNa) and Calcium Chloride (Cl<sub>2</sub>Ca), in a solid state or as liquid brine. Their use depends mainly on the type of treatment that is to be applied and the foreseen temperature. It is advisable to use them in accordance with the specifications of the following chart:



TREATMENT	TEMPERATURE	FLUX
PREVENTIVE	above -15°C	Sodium Chloride (ClNa)
	equal to or less than -15°C	Calcium Chloride (Cl <sub>2</sub> Ca)
CURATIVE	Above -5°C	Sodium Chloride (ClNa)
	below -5°C and above -15°C	2/3 Sodium Chloride (ClNa) + 1/3 Calcium chloride (Cl <sub>2</sub> Ca)
	below -15°C	Calcium chloride (Cl <sub>2</sub> Ca)

In executing preventive treatment against snow or ice, the way in which the flux is used and the resources will depend basically on the state of the road and the relative air humidity. The guideline values are set forth in the following chart:

STATE OF THE ROAD		FLUX	RESOURCES (gr./m <sup>2</sup> )
DRY ROAD	Relative humidity < 75%	ClNa liquid brine	5 – 10
	Relative humidity > 75%	ClNa or ClNa wetted with ClNa brine	5 – 10
SLIGHTLY WET ROAD		ClNa or ClNa wetted with ClNa liquid brine	5 - 10
VERY WET ROAD		ClNa	10 – 15

In curative treatments against snow, the way in which the flux is applied and the resources will depend basically on the type of snow, working temperature and thickness (e) of the snow. The approximate values traditionally used are those shown in the following chart:

TYPE OF SNOW	TEMPERATURE	FLUX	RESOURCES (gr./m <sup>2</sup> )	
			e < 2 cm.	e > 2 cm.
MELTING	t > -5°C	ClNa	20 – 30	30 – 40
	- 5°C > t > -15°C	2/3 of ClNa + 1/3 of Cl <sub>2</sub> Ca	20 – 30	30 – 40
	-15°C > t	Cl <sub>2</sub> Ca	15 – 20	20 – 30
DRY OR PACKED	t > -5°C	ClNa wetted with ClNa liquid brine	20 – 30	30 – 40
	- 5°C > t > -15°C	2/3 of ClNa + 1/3 of Cl <sub>2</sub> Ca wetted with ClNa liquid brine	20 – 30	30 – 40
	-15°C > t	Cl <sub>2</sub> Ca wetted with Cl <sub>2</sub> Ca liquid brine	15 – 20	20 – 30

The basic criterion applied by the Directorate General of Roads in designing the Winter Maintenance Operating Plans is ANTICIPATION.

This anticipation is shown in the execution of the preventive work. This entails the need to make a preliminary deployment of the snow-removing equipment when it is foreseen that there will be snowfalls. For this purpose, it is considered that each piece of snow equipment is put in place before the snow starts to fall, at strategic points along the assigned route. Likewise, this anticipation is also evident in the establishing of traffic restrictions. As already mentioned, the preventive restriction of heavy vehicles forms a part of the strategies established in the Operating Plans and is intended to prevent heavy vehicles from straddling the roads and blocking them. In this respect, as soon as the state

of the road may entail a risk for heavy traffic, i.e., leading to the possibility of their straddling the road, restrictions are placed on this type of vehicle to facilitate the movement of the other vehicles and allow the snow machines to do their jobs.

All the strategies established in the Operating Plans are developed within the appropriate framework of coordination between the different institutions taking part in the System maintenance, i.e., fundamentally those responsible for Traffic and those responsible for Roads, and become evident particularly when establishing limits on the driving of vehicles, which is done jointly by the responsible persons from those institutions on the roads themselves.

As all these circumstances are set down in the Winter Maintenance Operating Plan of each sector, the quality of the service provided is based on the extent to which the plan is complied with.

## **5. EMERGENCY PARKING FACILITIES**

To facilitate and allow for improved operations in restricting the driving of heavy vehicles, the Directorate General for Roads is in the process of implementing a programme for building a series of large-capacity parking facilities located at strategic points where vehicles that are unable to move due to winter road conditions can park in an orderly fashion. In 2005, the Sub-directorate General for Maintenance and Operation drafted a framework document defining the general characteristics of these parking facilities and the areas in which they are located, based on their accessibility, the existence of nearby catering and accommodation services and above all, the climatic conditions of the nearby road sections during the winter months.

This programme currently considers the building 56 parking facilities, of which 8 have already been built and are operating, 25 are being built and 23 are planned to be built. The total planned investment amounts to 116.58 million euros.

For the 2009/2010 season, it is planned that 23 of these parking facilities will be operating, representing 41% of the total.

## **6. REFERENCES**

1. Ministry of Development. Service Note concerning the activities of road maintenance services during winter maintenance campaigns, issued in October 2006.
2. Coordination Protocol of the General State Administration Institutions in the event of heavy snowfalls and other extreme weather conditions that could affect the National Roads System, issued in March 2009.
3. Ministry of Development. Winter Road Conditions, Technical conditions and resources, issued by the General Directorate for Roads in 1988.