Alusuisse
puts aluminum
in motion

RATP – Régie Autonome des Transports Parisiens

Metro Paris

Subway car, type MF77 in self-supporting, welded aluminum design

Photo RATP

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ALUSUISSE

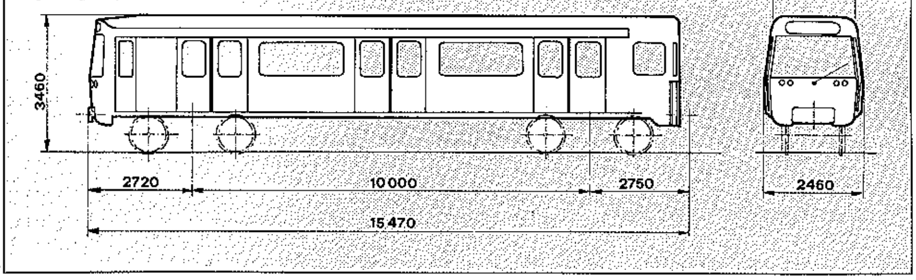
Weighty arguments in favor of a lightweight metal

If you travel in an up-to-date, comfortable passenger car of the Metro Paris, speeding somewhere between the Porte de Clichy and the Madeleine, or make a journey from the Montparnasse to the Place de l'Opéra, you travel in a vehicle made of aluminum.

If you are looking for cost-effective, systematic and streamlined solutions to transportation problems, perhaps you will remember the Paris Metro... and Alusuisse, a company which contributed significantly to the construction of the new rolling stock.

In partnership with the railcar builders Franco-Belge Alusuisse engineers succeeded in underbidding the cost for steel car structures, thanks to the new large-section technology.

Power car



Technical project-related details

Project:	1,000 vehicles type MF 77, assembled as 5-carriage trains (3 power cars and 2 intermediate carriages)	
Power car:	Empty weight Car body shell weight 45 seats, 132 standing passengers	27,000 kg 3,050 kg
Intermediate car:	Empty weight Car body shell weight 52 seats, 136 standing passengers	20,000 kg 3,050 kg
Design:	Self-supporting, welded aluminum construction, using large aluminum extrusions	
Services of Alusuisse:	Stress analysis design of body shells. Supply of aluminum semis Alusuisse alloys: Extrusions: Anticorodal-062® (AlMgSi0.7/AA6005A) Sheets: Peraluman-300® (AlMg3/AA5754)	
Manufacturer:	SFB — Société Franco-Belge de Matériel de Chemins de Fer, Raismes	
Years of manufacturing:	1977–1981	
Transit authority:	RATP — Régie Autonome des Transports Parisiens Gauge 1,435 mm Maximum speed 100 km/h Maximum acceleration 0.85 m/s² Continuous power rating 6×260 kW per train set	

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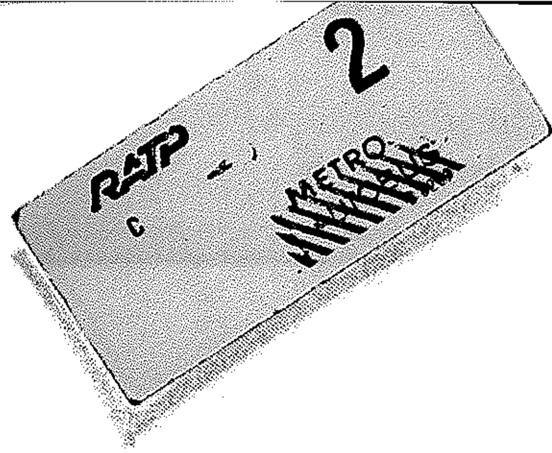
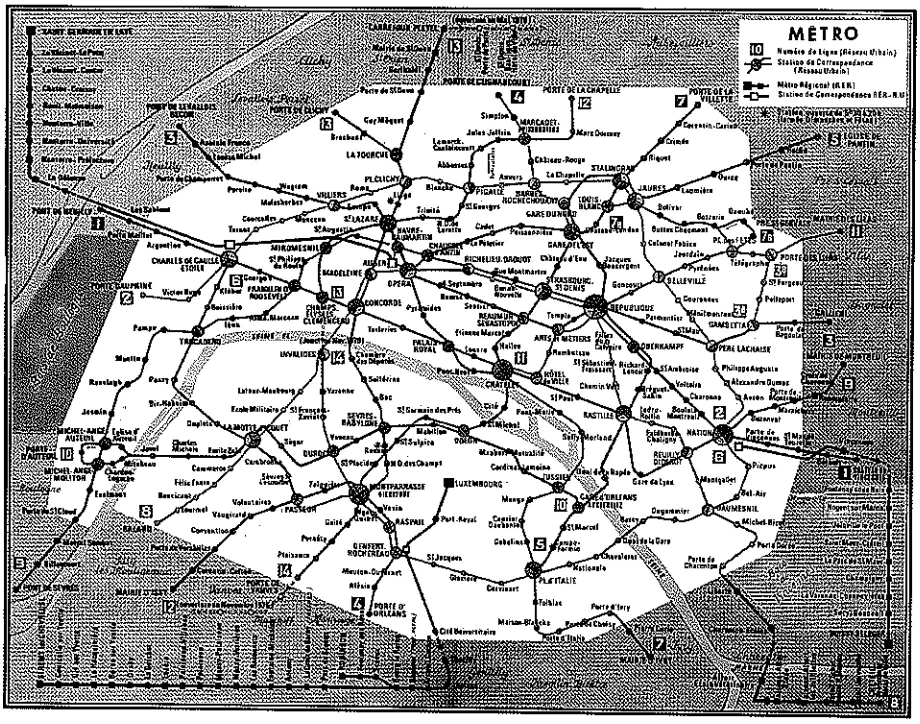
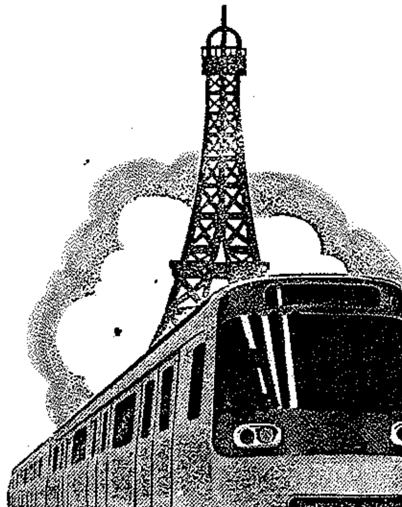


The Metro Paris requires a new generation of passenger cars

The decision of the Metro Paris to choose aluminum for the construction of a new passenger car generation, opened a new chapter in the fascinating story of rail travel.
A chapter, under the co-authorship of Alusuisse. It is not a new discovery that aluminum is lighter than steel. And the fact that steel is cheaper than aluminum is no news, either. In spite of this, the choice of aluminum worked out lower in price than the other offers in steel. A secret? Not at all. Just the practical application of the logical consideration that not everything depends on the alloy but rather what we make of it.
What can be made of aluminum and how it is made, is demonstrated by Alusuisse engineers by the example of the Metro Paris. By the way, an example which can serve as a model for the solution of future vehicle problems.



The increase of the population, the roads hopelessly congested by the private traffic during rush hours, obsolete public transportation means: that was the starting point.



To expand the network of the Paris Subway System, to construct new lines and to modernize the rolling stock that was a bold attempt for a solution.
With 4,000 vehicles, 1,200 million passengers per annum and a network of 275 kilometers, the RATP (Régie Autonome des Transports Parisiens) was founded in 1900 and belongs to the first underground railway systems of Europe. The approved loan of 1.2 billion French francs for the procurement of a new generation of vehicles proves that the Metro Paris wants to remain one of the most up-to-date and efficient rapid transit systems.

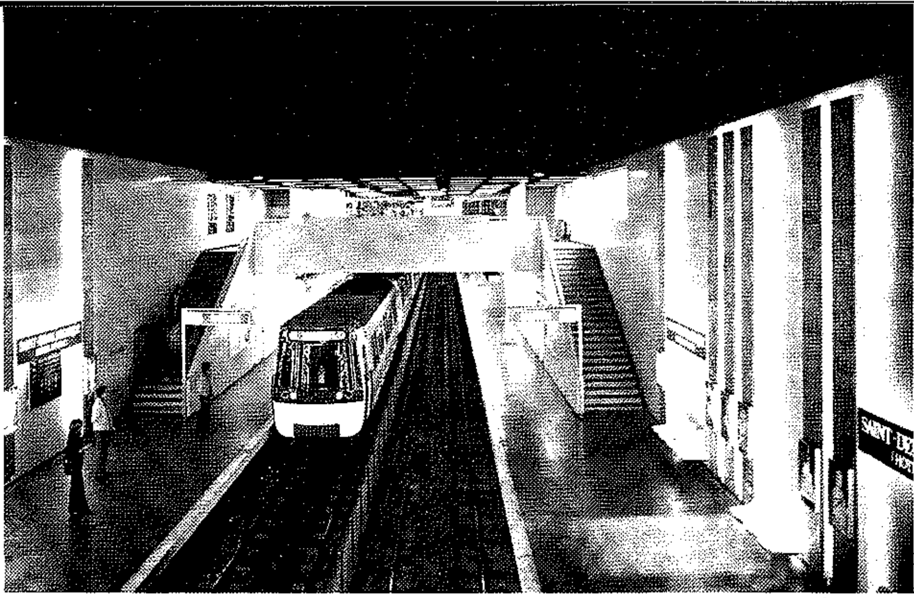
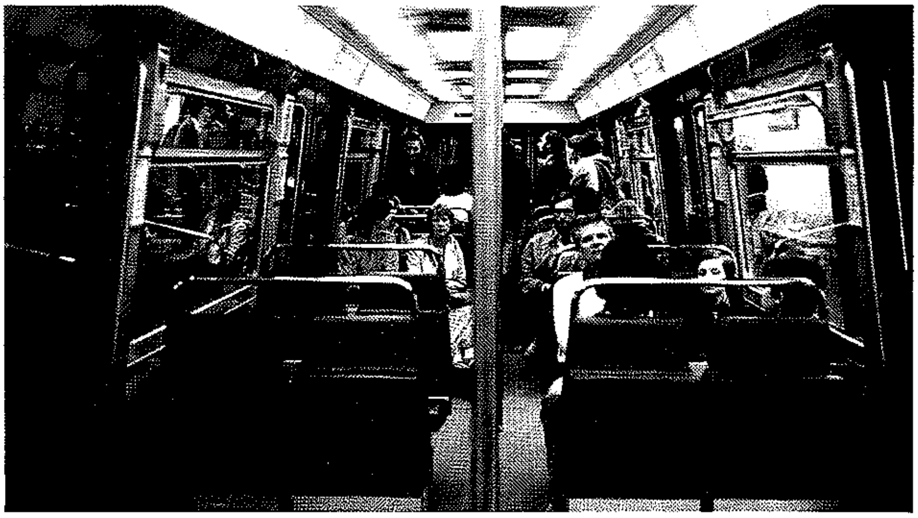


Photo RATP



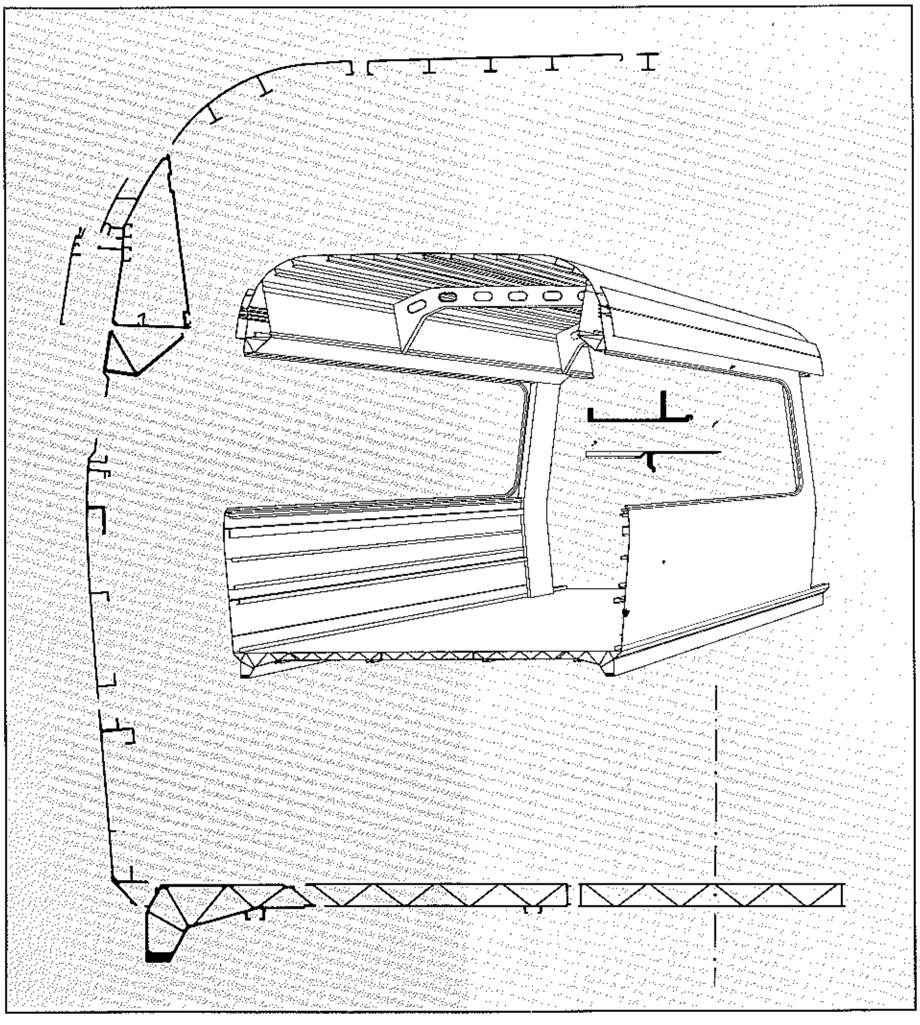
The tender and its most important criteria

The well-tried concept of five-car multiple units is to be maintained. Every train unit must consist of 3 power cars and 2 trailer cars. With a fleet of 1,000 vehicles, this amounts to 200 multiple units. The solution proposed must be flexible. That is, on new lines, it must later be possible to use six- or seven-car train units.
These were the requirements as defined by the general RATP tender addressed to the railway car industry.

Further criteria were:
- Convex side walls, to optimize the utilization of the existing loading gauge and to provide the passengers with more elbow room.
- Three-part type body shell: the front and the back of the body easily detachable from the middle vehicle structure, to make it easy to rebuild the cars later, if required.
- The design of the car structure for 6–8 persons per square meter, corresponding to approx. 200 passengers. These details refer to the extreme case. The normal load was given as 28 passengers seated (intermediate cars), 20 passengers seated (trailer cars) and 165 passengers standing (all types of cars).
- Possibility to submit quotations for cars with steel or aluminum structures.

Light aluminum wins against arguments as hard as steel

The "big four" of the international passenger car industry applied for the interesting large-scale contract of the Metro Paris. One of these companies, the Société Franco-Belge de Matériel de Chemins de Fer, selected Alusuisse as competent partner to provide the design and development work for the aluminum alternative.
The starting position for Alusuisse was clear. It meant – expressed in simple terms: "Better and at a lower price than steel!" The traditional design, the use of plates and small sections, had to be discarded. Alusuisse was forced to find a solution with a brand-new technology. This new technology existed in its basics. For the RATP, it was applied for the first time, persistently and successfully.



The aim of the new technology: To reduce workshop hours and not only to compensate the higher price of aluminum as a raw material, but also to underride the costs of a rough body shell made of steel.

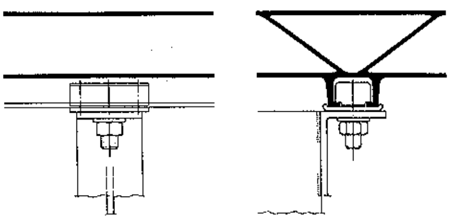
The means of the new technology: Persistent application of large sections. The integration of as many additional functions as possible into the individual sections.
The new technology won the battle: the Alusuisse aluminum car structure is designed in such a way that the fabrication costs are considerably reduced. The partners of Alusuisse, the Société Franco-Belge de Matériel de Chemins de Fer, were able to estimate the construction of a body shell with 500 working hours, thanks to the "Alusuisse design" which has already gained a reputation in professional circles.
The application of this special technology made it possible for the first time to fabricate a car body of aluminum at a price which is 30% lower than that of one of steel. This was the main factor beside the usual specific advantages of aluminum.
The Alusuisse partners Société Franco-Belge received the appealing contract of the Metro Paris.

The super solution: Supersections with multifunctions

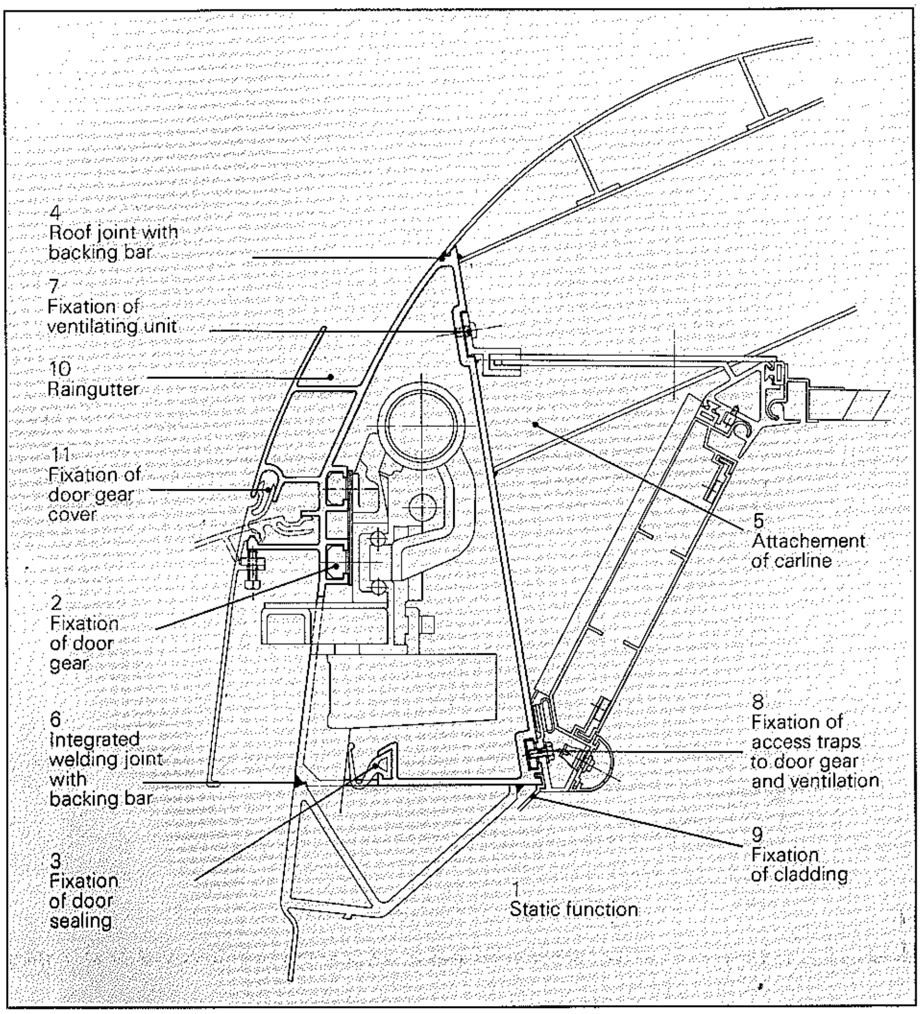
A new Alusuisse profile with specific profile know-how

18 longitudinal large sections (10 different cross-sections) interconnected by 24 longitudinal automatically welded joints, 10 hand-welded frames in the sidewall/roof area: this is the new vehicle design.
Various horizontally aligned sidewall and roof brace ribs have several simultaneous functions:
- Fixing of cladding, doors, heaters and ceiling-mounted lights, etc.

The floor sections with their longitudinal rails permit simplified mounting of the underfloor equipment.



Not only the supersection technology alone was responsible for the drastic cut in fabrication man-hours, but also the persistent application of the extrusion technology, which resulted in the integration of several fastening elements in one single extrusion.
For example, the longitudinal roof girder: "Supersection" with 11 different functions.



Seventh Annual International Aluminum Extrusion Design Competition:

The Winner: ALUSUISSE!

In the international competition of outstanding design of aluminum sections in the category "transportation" the Alusuisse Supersection won the 1st prize.

The victory over competitors was primarily the victory of Alusuisse large-section technology. The advantages of aluminum as a light material, coupled with extrusion technology resulted in the following:

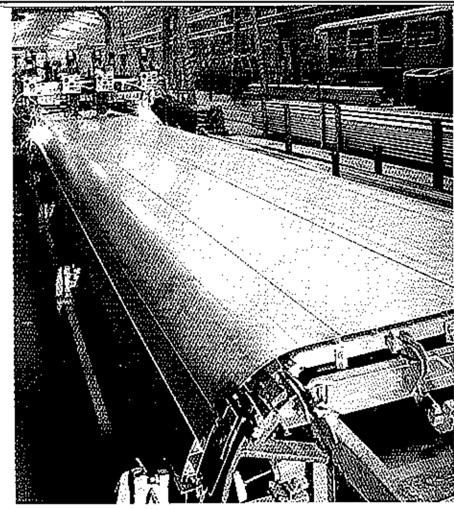
- reasonable price
- low weight

At the same time, a problem of first-rate importance was the question of alloying. Extensive design dimensioning and corresponding static calculations were necessary, until every section could be made of the easily extruded alloy Anticorodal-062®(AlMgSi0.7).
The advantages of this alloy:

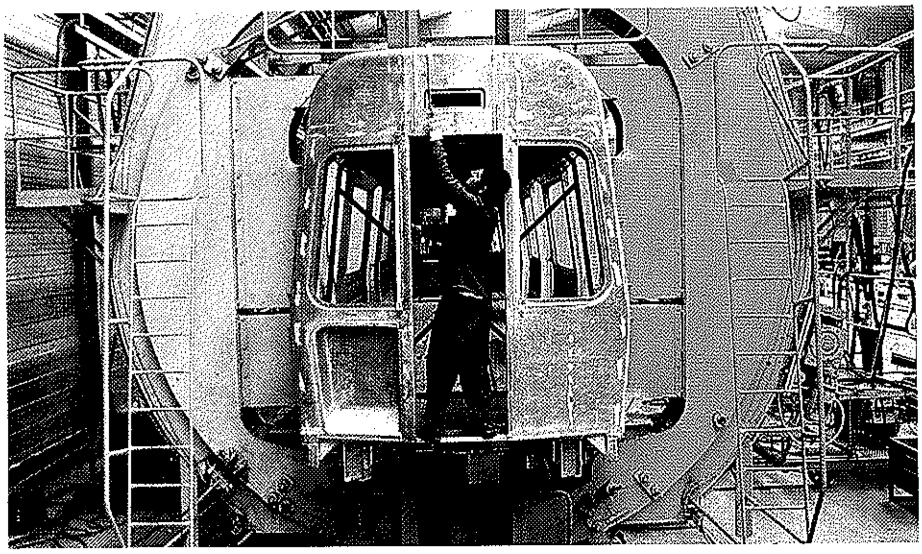
- easy to weld
- resistant to corrosion
- high strength (especially important to minimize plastic deformation in accidents

The car body shell of a subway passenger car weighs approx. 3 tons. For 1,000 passenger cars, this results in about 3,000 tons of aluminum semis required by Franco-Belge. The sections are up to 600 mm wide. They are extruded in vehicle lengths and transported in special cars by rail from different works directly to the customer.

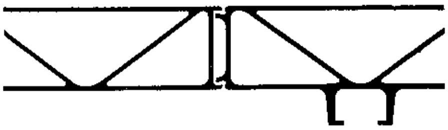
An assembly report



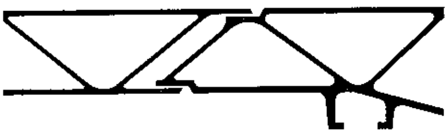
In the erection shops of Franco-Belge, more than 300 Metro cars are built annually. Due to the cost-efficient design, the required number of man-hours was drastically reduced.
One example: Self-locating joints between section sides. These simplify the jointing of the sections to be welded. They are pushed into each other according to the tongue-and-groove principle. Vertical sliding is avoided. Tack welding is not necessary. Sliding seats on the module separations equalize tolerances.
Nothing was forgotten to boost cost-efficiency, reduce labor and assembly costs. For instance, every component can be accurately prefabricated in special jigs, as the body shell is subdivided into various components: roof, side-walls, underframe, driver's cab, rear end.
Wherever possible, the edges to be welded and the respective backing bars are provided as integral parts of the extrusion. This makes sound single-V butt joints possible.
And one more contribution to cost-effectiveness: In the roof and in the underframe, the weld seams run along the total length of the car. The advantage: simultaneous automatic welding of several joints.



Samples of welding joints

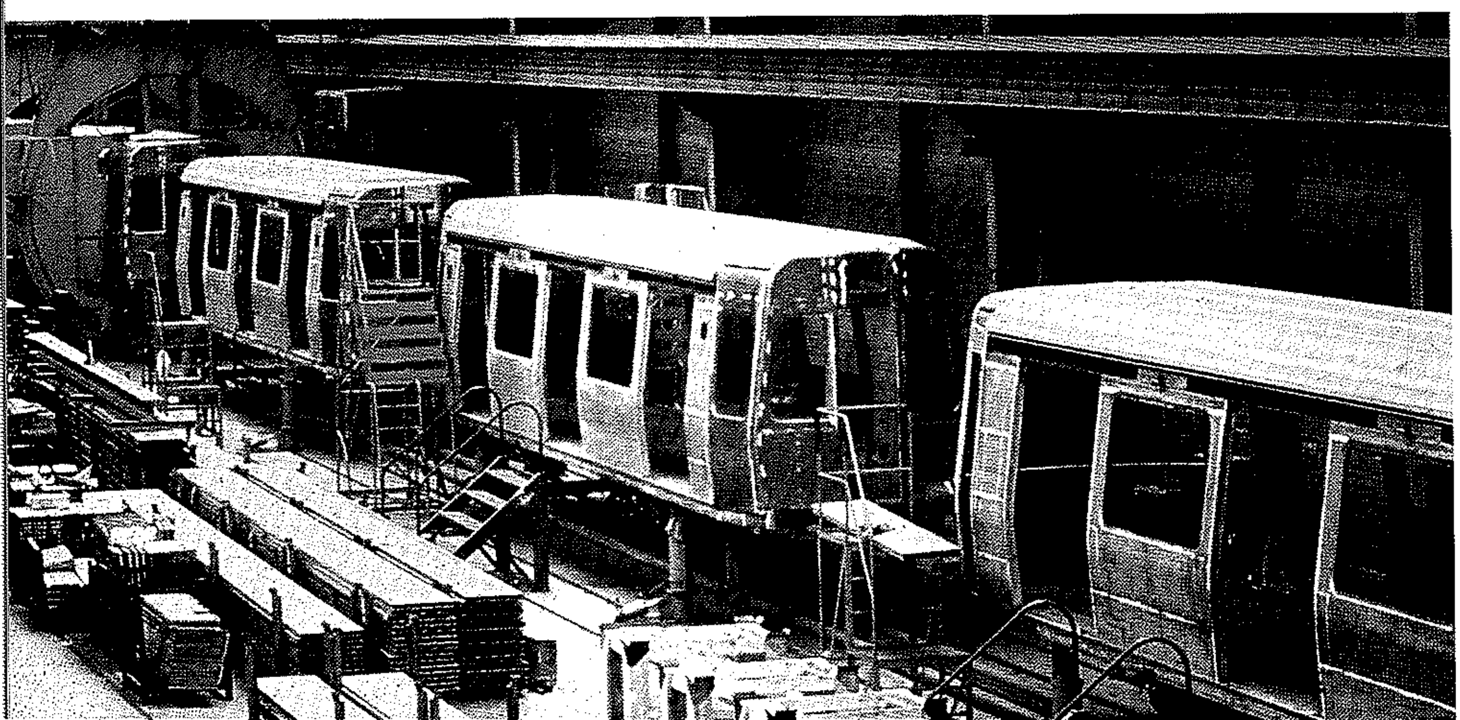


Joint between underframe sections with co-extruded weld bevel and centering device.



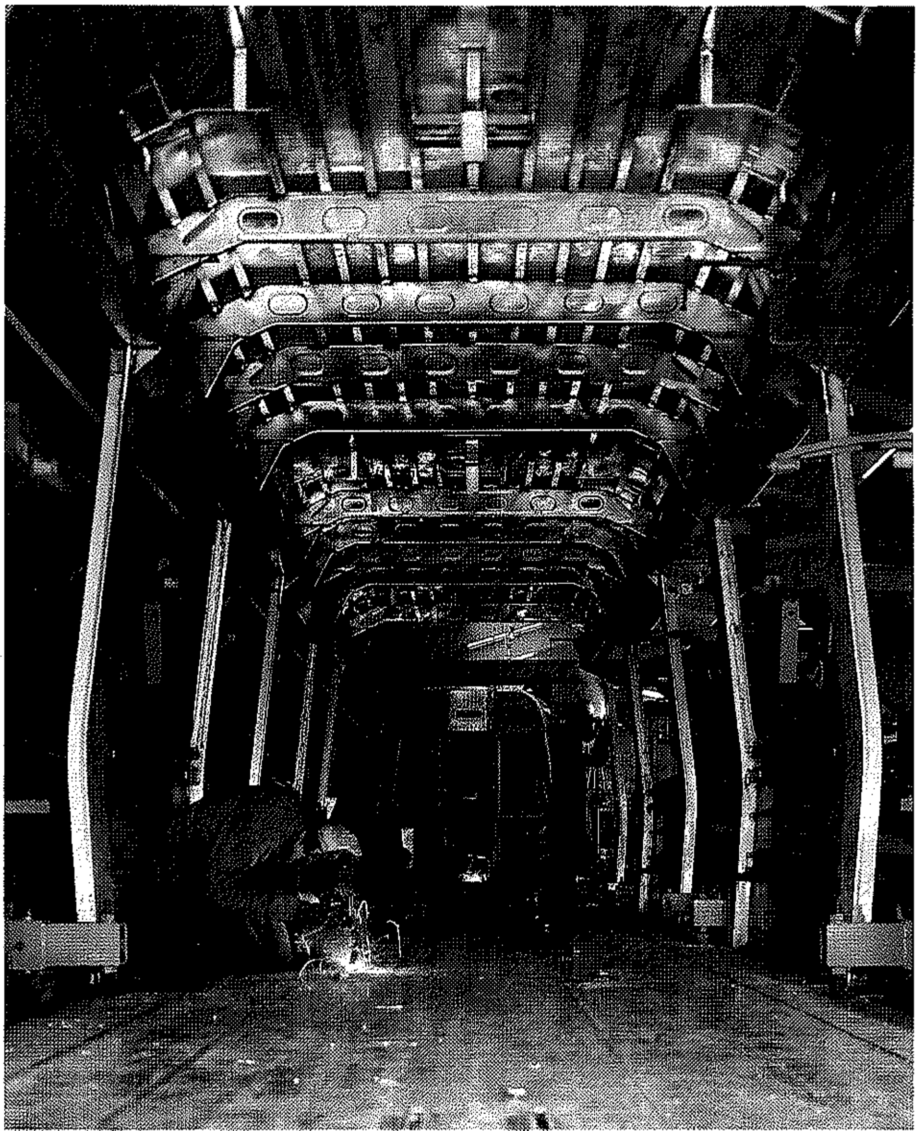
Dilatation allowing compensation of tolerances.

Joint between roof-extrusions with weld bevel, centering device and lids for easy clamping during welding.



The body shell passes hard performance tests

A reasonable price and cost-effectiveness are not everything. Safety and a long useful life are also important criteria. That is why the specifications for the Metro Paris car structure include quite an array of tests. Their objective: static and dynamic analysis of every extreme possibility.
Can the car structure resist a horizontal buffer load of 100 tons and a vertical load of 10 persons per square meter (corresponding to 700 kg/m² + equipment weight)? Is the service life of the cars really 30 years?
The customer rightly requested binding replies to these questions. These answers could not be given by computer analysis alone. The cars had also to be tested.



Therefore, the car structure was thoroughly tested in the installations of the neutral institute AIB (Association des Industriels de Belgique): The car structure was placed on a special, custom-built test stand and pulsated under increasing loads by 10^7 stress application cycles. This corresponds approx. to 30 years service life.
N.B.: This test facility was selected because it is the most suitable one of its kind in Europe for testing complete railway coache bodies.
However, apart from the expected service-life, RATP wanted several other important points to be checked:
- proof of strength of the bolster (static and dynamic)
- sound transmission of the floor structure
- sound transmission of roof and sidewall
- fire testing of a fully equiped vehicle end
- collision testing of the body shell, to determine its crashworthiness
- determination of the natural vibration frequency

The new light alloy Metro passenger car passed several qualifying tests with flying colors on the test stand – in every respect.
The submitted computations have been substantiated. The requirements of the customer were fulfilled.