

## COMPACT SYSTEM OF RADWAG AS AN ALTERNATIVE FOR MONOBLOCKS

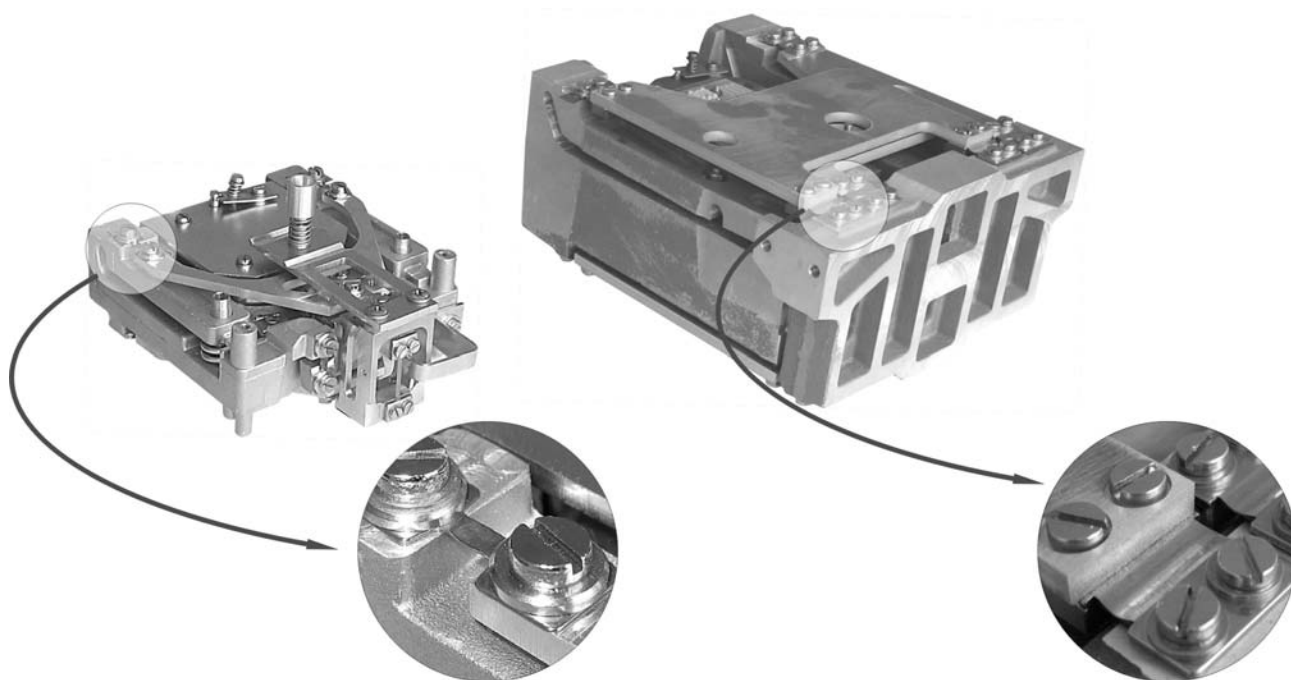
**Comparison of mechanical constructional solutions used nowadays by leading manufacturers of high resolution balances.**

Mechanical constructions of high resolution balances are divided into several types:

- a) traditional
- b) monoblock
- c) compact systems

**Traditional constructions** have been produced for over 20 years and allowed to develop kinematic pattern, which even today has remained unchanged. Currently offered constructions of balances made from, so called monoblocks, function with the same kinematic pattern. The name of the traditional construction has been adopted for balances with specific construction of bearing elements, whose functions are now served by springy elements (made of metal or bronze) so called flexures, mounted by screws to aluminium levers so called rockers.

The examples of such mechanisms manufactured at Radwag are presented in the pictures.

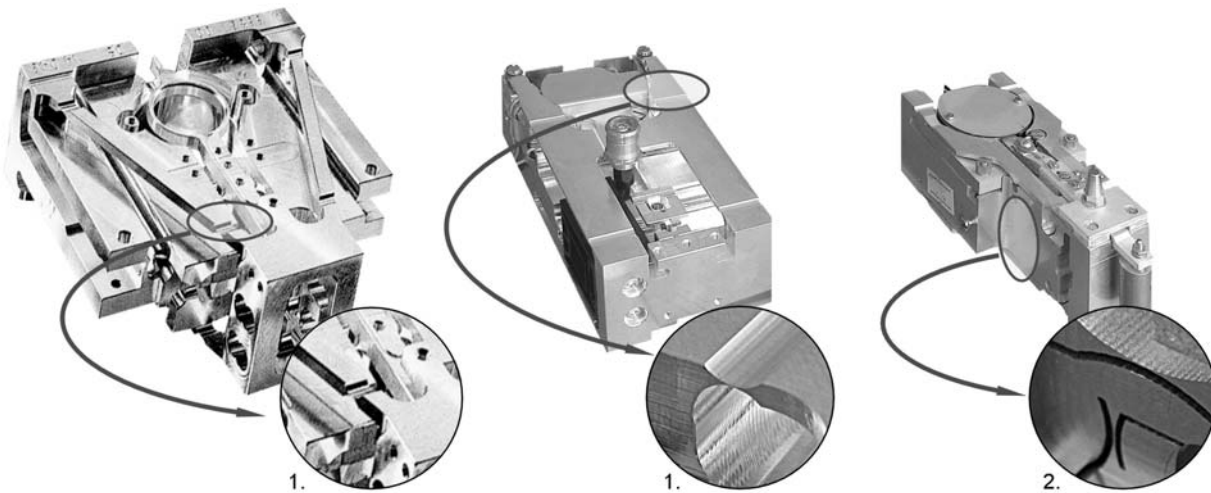


### Constructions of monoblocks

The main aim of European companies, seeking new solutions and investing significant financial resources into them, was to reduce the growing costs of workers assembling weighing elements and replace them with low-cost, faster and more efficient machines.

The first monoblocks offered in the market were characterized by significant errors (high hysteresis, temperature errors) and only after many years of research and introducing expensive, high precision machine tools it was possible to reach the resolution of 1-2 mln divisions. Even today, in professional solutions, some manufacturers are still using traditional system of flexures.

The examples of monoblock constructions sold today are presented in the pictures.



1. Example of monoblock manufactured using milling technology
2. Example of monoblock manufactured using string cutting out technology

### Constructions of compact systems

Many years of Radwag's experience in producing balances with high resolutions ( max 30 mln divisions) analyzing solutions of competition and our own research and development have resulted in creating a new solution, being a compromise in the field of measuring mechanism construction – **compact system.**

The first attempts of such solutions started many years ago, however only after the technology was fully developed the system could be used in most of Radwag's balances.

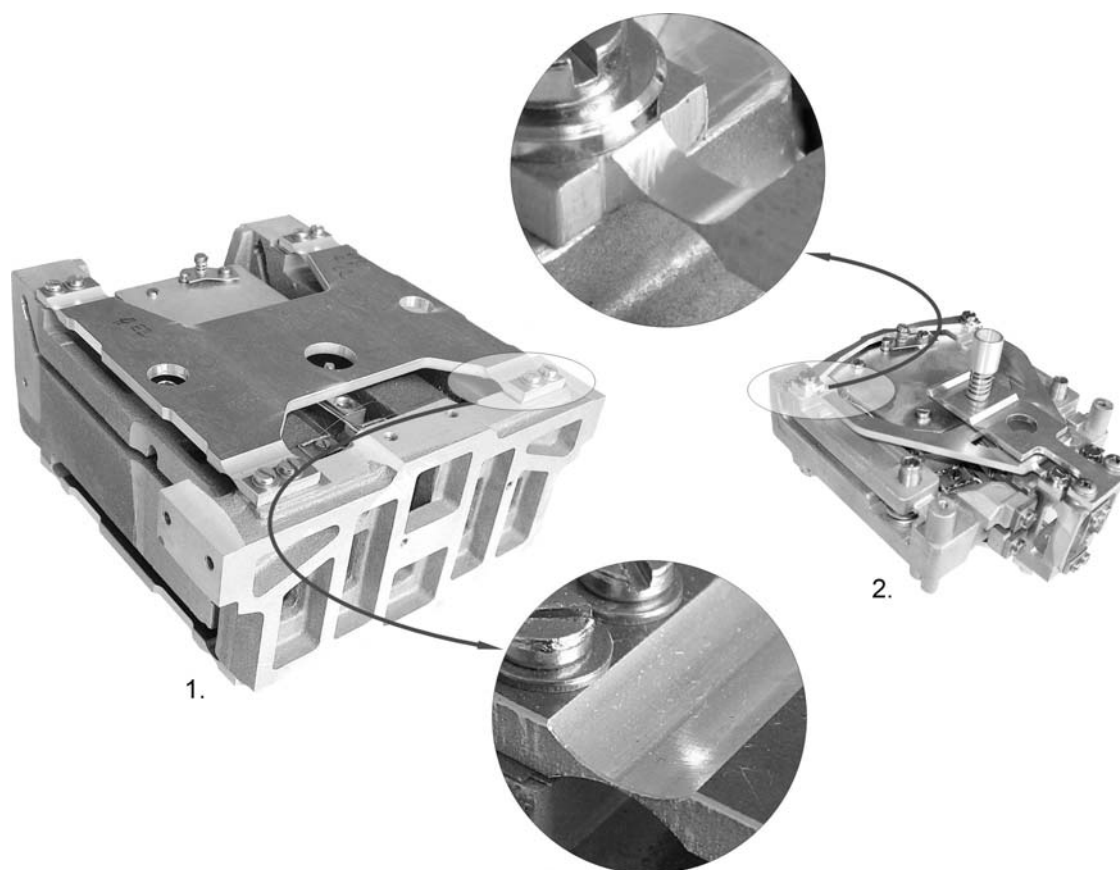
The fundamental principle of compact system is separation of components that require precision in their manufacturing and assembling from the body unit of the mechanism, in which, only the base surfaces are significant and possible to manufacture using milling technology with NC machines.

There two elements from traditional technology used in compact system: *string* – connecting the unit of measuring lever with parallelogram and the bearing of measuring lever.

These elements have the strongest impact on indication errors such as: linearity, hysteresis, zeroing, and using special materials (stainless steel, beryllium bronze) undoubtedly improves their quality and resistance against overload.

This solution eliminates basic problems connected with quality and repeatability of elements used for manufacturing traditional weighing mechanisms, and at the same time lowers production costs and enhances the quality. Bearing the above in mind, one can make a practical comparison between the construction of a balance and other solutions used in constructions of machines for example a combustion engine used in cars.

## Examples of compact systems used in Radwag's products



Example of compact system: 1 – balance series APP; balance series AS

The results achieved in Radwag after the introduction of compact system with the following balances: analytical balances series AS with the resolution of 3 mln divisions ( $d=0.1\text{mg}$ ), precision balances ( $d=0,1\text{mg}$ ) and precision balances series APP with 800 thousand divisions ( $d=0,01\text{g}$ ) have finally confirmed the purposefulness of the selected direction of development. The same quality as monoblocks, with lower implementation and more importantly, lower production costs, has been attained.

### Servicing of monoblocks and compact systems

Additional significant advantage of the solution currently offered by Radwag is solving servicing problems. Damages caused as a result of balance overload, transport shock, or destructive activity of weighing environment, in the case of monoblock, requires replacing the whole balance as servicing means assembling a completely new mechanism.

In the version with compact system servicing is much easier than with traditional mechanism, as only a complete unit of measuring lever is replaced and the exchange is carried out without breaking the structure of weighing unit i.e. actuator and A/C converter, therefore the temperature parameters remain intact. Only non-centricity and linearity correction requires adjusting. The cost of a single lever is obviously, much lower than the cost of the complete monoblock mechanism, which is reflected in the general cost and the cost of servicing.

Another significant factor is ecology. During the production process of monoblock, especially with older solutions of monoblocks, there is much more output material processed through machining with scabs requiring utilization.

There is significantly less waste material with casting technologies which predominate in compact system.

## Comparison of functional features of different types of mechanisms

Parameter description		Assessment of Construction against traditional mechanism	
		monoblock	compact system
Statistic weighing errors (hysteresis, linearity)	Due to higher durability parameters of elastic bearing elements (flexures) for correctly assembled traditional mechanism it is possible to reach lower errors than in monoblocks	-	+/-
Temperature errors (static and dynamic)	Statistic temperature errors are fully compensated by electronic units and cannot be omitted. Dynamic errors depend on correctness of specific mechanical and electronic constructions and their size cannot be only associated with the type of traditional mechanism, monoblock or compact system.	+/-	+/-
Weighing time	Weighing time depends mostly on electronic solutions applied. For electromagnetic balances, weighing time depends, to a small degree, on the mass of weighing elements, which does not move while weighing, which results from work principle of mass determination system applied.	+/-	+/-
Resistance against transport shocks and overloads	Theoretically, better durability of flexures should favour balances with traditional mechanism extended and commonly used in all made mechanisms additional protecting elements determine the durability of the specific balance against shocks and transport.	+/-	+/-
Labour intensity of assembly	Due to quantity of parts and the necessity to mount them with high precision, assembly time of monoblock is the shortest, assembly time of traditional mechanism is the longest and assembly time of compact system is medium.	+	+/-
Labour intensity of manufacturing parts	Generally the cost of manufacturing monoblock in comparison with traditional mechanism is very high due to very high costs of operating expensive machine tools for metal processing. In compact systems in comparison with monoblocks, high precision machining is applied to a small number of elements, and the body unit of mechanism is made as aluminium casting where only insignificant part is machined.	-	+/-
Production costs of mechanism	Production cost is the sum of manufacturing costs and assembly costs. With high costs of hand-made materials, in the older countries of UE, it is justified to replace it with machine made materials. However, in the final estimate, the production of compact solution, being a compromise, which guarantees high quality of balances and with Polish wages costs is the most beneficial. It is confirmed by the prices of balances offered in the market.	+/-	+/-
Servicing	Servicing costs of mechanical elements are definitely the lowest for compact systems. Replacing rocker sets is fast, does not require special instruments and does not trigger the necessity of correcting temperature parameters. In the case of monoblocks the whole damaged monoblock needs to be replaced which is easy for the service but very expensive for the end customer.	-	+
Material wear and energy consumption (ecology)	During production process of monoblocks, especially the older versions, there are more output materials processed through machining and with newer versions there is more energy consumed for machining than in the case of shape cut out using a string.	-	+

## Conclusions:

1. As a result of research made by within 30 years of laboratory balances (mostly electromagnetic scales), different solutions of replacing traditional, mechanical systems were found. Main reason for this modifications were to decrease production costs of scales in Europe, which were high because of increasing wages of workers. The reason for waiting long for positive effect was a problem with monoblock quality comparing to traditional solutions.
2. Scales equipped with monoblocks or compact systems are not better or worse in general than traditional systems. Scales with monoblock supposed to be cheaper in general, than traditional ones, but the actual prices do not reflect it.
3. The concept of compact system introduced by RADWAG is a solution, being a compromise, that limits high precision and expensive work of technicians. Price of manufacturing is lower which combined with high quality allows to compete with other producers.
4. Servicing of RADWAG's compact system is incomparably cheaper and faster than monoblock. It is very important for clients' costs of "after sale service".
5. Balances with very high resolutions: microbalances with  $d=1\mu\text{g}$ ;  $d=0,1\mu\text{g}$ ; or analytical balances with  $d=0,01\text{mg}$  are produced by most of manufacturers and are based on traditional systems which destroy monoblock market reputation as most precise and most stable weighing system.

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