

Performance Data and Graphs on the "Warehouse Core" System



Flow storage has undergone continuous development in recent years, with technological innovations in flow storage technology and successful links with partial and fully automatic operating techniques leading to new system and integration concepts. This development at all levels has led to the development of new application functions and focus industries. Flow storage technology presents an attractive logistics-based and efficient alternative to conventional racking techniques within defined storage parameters.

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Introduction



The Department of Planning and Control of Storage and Transport Systems at the Leibniz Universität Hannover, Germany has collated relevant influencing factors and compared flow storage technology with conventional static racking to present efficient applications for flow storage technology. Their calculations were based on investment and cost variables commonly applied in Western Europe. The results and following information are based on order picking warehouses with standard pallets.

The goal of the study was to ascertain the optimum storage volume, i.e. the ideal length, width and height dimensions of the warehouse core, according to the racking technology used. Full enumeration was used to calculate all the feasible options and select the optimum solution.

Executive Summary

The study analysed optimisation goals, key factors in the planning of a warehouse, including the minimum floor space requirement, lowest investment costs, as well as lowest operating costs. The storage capacity required, as well as the hourly storage movements, were used as the guideline variables when calculating the comparison.

Further influencing factors included the warehouse operation technology used, the temperature of the warehouse, the dimensions and weight of the load units being stored, the operating hours, staffing and energy costs, real estate prices and the warehouse to be constructed.

A number of practice-based combinations of guideline variables and factors were calculated using a computer-aided model and key performance data and graphs were produced. This offers designers and decision-makers the benefit of not just presenting one operating situation but clearly showing progressions and trends. This will enable future developments, such as increasing warehouse movements, to be taken into consideration in the decision-making process.

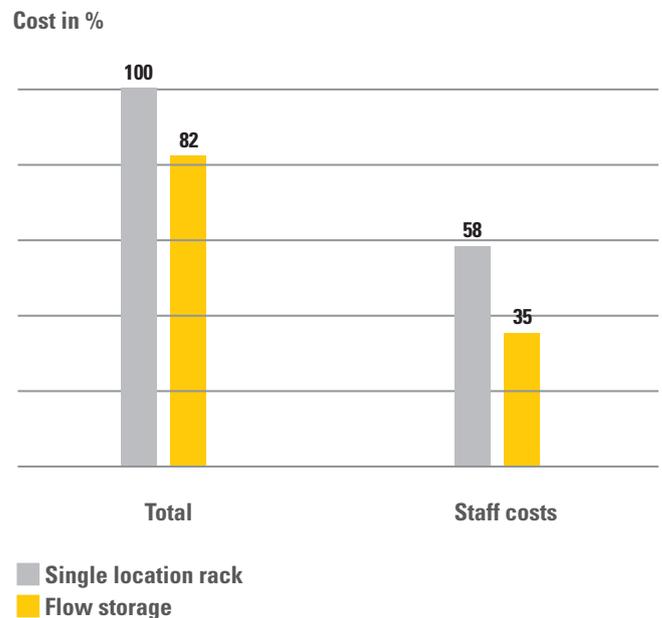
The operating costs given in the diagrams include the staffing, energy and maintenance costs within a defined period. The sum of operating costs and calculation-based costs are defined as total costs. The key parameters are listed for each diagram: capacity, optimisation goal, warehouse operating technology, warehouse temperature and throughput.

The performance data and graphs produced are intended to serve as indicators to aid decision-making processes regarding the choice of a storage system to meet specific requirements and aim to limit the choice of options available to designers and decision-makers to technically feasible and economically attractive solutions.

More specifically, the following facts have been derived from the results:

- Retaining the same capacity, with a smaller number of different characteristics of load units, the lane depth

Total improved cost, Reach truck, 5000 LUs, 150 LUs/h, Normal temperature



can be increased and the number of lanes reduced – a typical characteristic is the similarity of items. With otherwise identical framework parameters, the efficiency of storage systems using flow storage technology improves and the floor area required is reduced.

- The shorter distances involved when operating a flow storage system reduce the need for floor transport vehicles and staff. As the warehouse movements increase, the overall cost of a flow storage system increases less rapidly than would be the case with a warehouse with single location racking.
- Less energy is required to heat or cool a warehouse due to the smaller structural volume of flow storage systems, whilst retaining the same capacity. In cold stores, and especially in refrigerated warehouses, this constitutes a significant benefit in terms of cost, in view of predicted rising energy prices and further underlines the environmental benefits of this system.
- The unused free space in flow storage systems due to the inclined lanes is more than compensated for by the reduced floor area required for the flow storage system itself.

Operation

The structure of the lanes is what characterises flow storage systems. The lanes are fitted with non-driven rollers and load units flow thanks to the use of gravity from being fed into the lane to being delivered for removal from the lane. The load units run through the lanes over rollers, with braking rollers controlling the speed of the load units.

A separator at the end of a lane ensures that even several accumulated heavyweight load units move forward gently once a load unit has been removed and the load unit supplied for removal from each lane is generally positioned in a non-accumulated manner for removal from the lane with ease. Flow storage systems provide for compact storage with lane depths ideal for up to 50 pallets.

Flow storage systems are the perfect compact and energy-efficient technology wherever storage is required for fast-moving items and for a limited number of different items and whenever a logistics system based on the low use of resources is called for. Efficiency comparisons with conventional storage technologies underline this.

The temperature in the warehouse affects the overall cost and a differentiation is generally made between normal, cold and refrigerated storage. Normal warehouses are not climate controlled.

Total improved cost, Reach truck, 150 Lus

Temperature	Total cost as a %		
	Capacity in Lus	Single location rack	Flow storage
Normal temperature	5.000	100	81
	10.000	122	126
	15.000	147	157
Refrigerated warehouse	5.000	139	111
	10.000	192	168
	15.000	250	218

Improved operating costs, Reach truck, 150 Lus

Temperature	Operating cost as a %		
	Capacity in Lus	Single location rack	Flow storage
Normal temperature	5.000	100	60
	10.000	102	79
	15.000	104	80
Refrigerated warehouse	5.000	115	71
	10.000	128	96
	15.000	144	100



Adaptability

Flow storage systems are also characterised by their scalability. Increasing the number of load units with identical characteristics can be achieved by lengthening the lanes; increasing the characteristics of load units can be achieved by increasing the number of lanes. The characteristics of a load unit could be the type of item itself, its best before date, supplier, destination, transport route, sequencing, height or weight of the load unit, article group etc.

Throughput can be increased by increasing the upstream and downstream operating technology. Depending on the specific case, either the number of interacting user-operated or automatic conveyors is increased or several sections are switched by assigned automatic units, such as racking control units. Automatic control units supply the unloaded load units at a defined point for transport within the company. An appropriate interface has to be created for the load units to be stored.

The available floor transport vehicles range from all kinds of user-operated electric lifting trucks, counterbalanced lifting trucks, reach trucks and very narrow aisle (VNA) trucks. User-operated floor transport vehicles can simultaneously operate the flow storage system and provide transport within the company, making the time-consuming and expensive interface between warehouse operation and internal company transport redundant.

Flow storage systems fully meet the need for flexibility in terms of capacity and performance, as can grow as the company grows. Thanks to their versatility, flow storage systems are uniquely suitable for retrofitting or for a change of storage technology system.

More than ever in this age of limitless choice of location, mobility is a key selection criterion for storage facilities, ensuring that staff and the technology can accept the necessity of moving location. In terms of the warehouse facilities per se and their operating technology, it is essential that the equipment can be dismantled at one location and reassembled at another location with ease, quickly and cheaply, something that can be done with ease with flow storage systems.

Applications



**Total improved cost, Reach truck, 5,000 LUs,
Normal temperature**

Turnover in LUs/h	Total cost as a %	
	Single location rack	Flow storage
50	88	92
150	155	139
250	222	187

Flow storage systems are used in production, retail and the service sector and can be operated as partially automatic or fully automatic systems in almost all sectors and are used worldwide, both in industrial nations as well as in developing countries.

In production they are often used to separate the flow of parts from different manufacturing sections as a buffer in the main flow. Flow storage systems can take on a 'feed' function on the one side of the racking, serve as a buffer and ensure the proper flow of goods in the lanes and provide a supply and

removal function on the other side of the racking. The flow function in the lanes, from input to output, is "automated" by gravity and is therefore performed without the need for an operator.

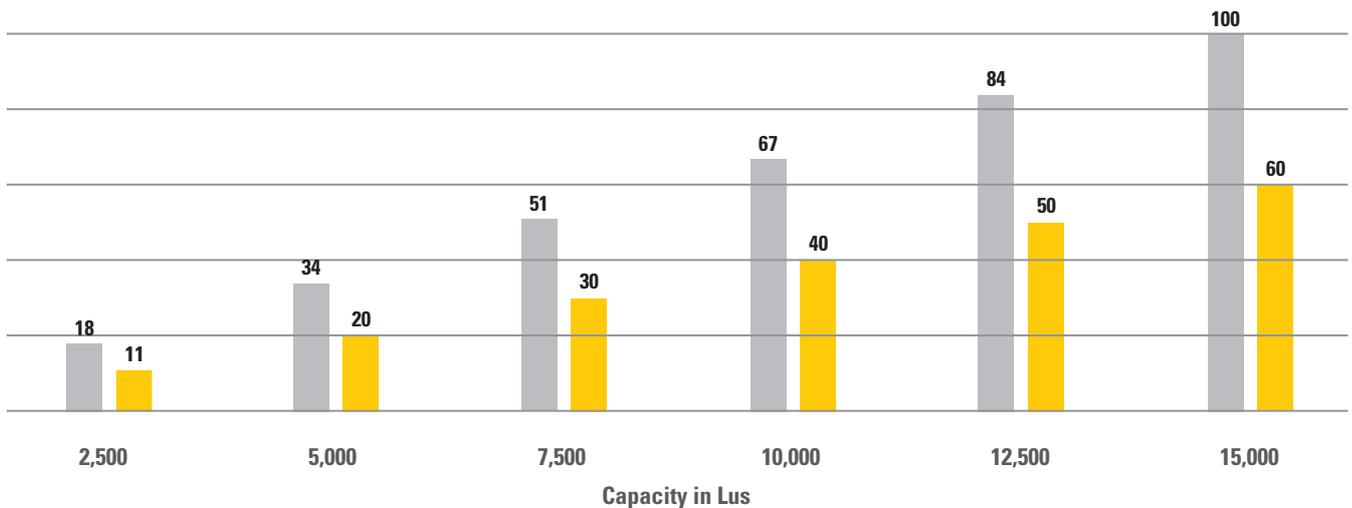
Flow storage systems are characterised by their outstanding energy efficiency, as thanks to their compact construction, floor space can be saved and overall the system is more environmentally friendly. The storage technology can be erected where required within the building and is therefore completely independent of the building itself.

For example, assemblies can be fed sorted from prefabrication into the relevant lanes and then be supplied in a forced return system based on the First in/First out principle for final assembly. Once the operative has reached the output lane with the assigned pallet, these pallets can be removed without the need to search for a dedicated storage location. Thanks to their operating principle, flow storage systems independently create order within a warehouse.

At the picking stage, flow storage systems can be combined for replenishment work and for static supply for removal. The replenishment item is placed in the upper section of the racking and is delivered for picking in the lower section. The replenishment and picking lanes are provided with a counter-incline so that picking and replenishment actually take place at two separate sides. Replenishment and picking can be done at the same time, without impeding each other.

Optimised floor area, Reach truck, 150 LUs, Normal temperature

Floor area as a %



■ Single location rack
■ Flow storage

Technology and Efficiency



Gravity is used in flow storage systems to transport the load units from the input to the output. There is no need for drive motors and thus costly control and regulation work is not required. Standard components are essentially used for flow storage systems, ensuring simple spare parts logistics. A long technical lifetime can be assumed providing high-quality components are used for the worn parts. Fundamental logistics experience also applies here, in that quality has its price, that is this additional investment will pay for itself in the medium to long term.

Maintenance and repair work can therefore be carried out inexpensively, thanks to the standard components used, the simple controllability of the system and its transparency. Flow storage systems are exceptionally durable and guarantee high-quality, long-term logistics for all operators.

The construction of the rollers used is crucial with flow storage systems, as they have to ensure the parallel and silent progression of the load units, at the same time, the gentle incline of the racking can only be produced if ultra-

smooth running rollers are used, which also operate quietly. With lanes of up to 60 metres in length, the degree of incline of the lanes creates unused free space above and below the racking due to the configuration of the system, thereby reducing the level of use of the volume of the building.

Over and above its structural and technical characteristics, it is imperative when selecting a suitable racking type that the associated effects on the energy requirement for transport and the air conditioning of the building are also taken into consideration.

The principles of an energy-efficient storage system have to be defined at the planning stage when key decisions are made about the dimensions and design of the building, closely linked to the chosen racking technology and operating technology. The structure of the building specified and built can only be revised or adapted at great expense to meet changed requirements, underlining why decisions at the planning stage have to be taken carefully with a view to possible future changes.

**Total improved cost, Reach truck, 5,000 LUs,
150 LUs/h**

Temperature	Total cost as a %	
	Single location rack	Flow storage
Normal temperature	100	81
Cold store	116	94
Refrigerated warehouse	139	111

The volume of the building should be checked first and foremost with regard to the installation of an energy-efficient storage system. The crucial point at this stage is that the energy requirement is influenced in particular by the heating or cooling of the building.

An oversized building height, which is unused by the racking system and the floor transport vehicles used, leads to unused volume that nevertheless has to be heated and cooled. It should be noted that the importance of an optimum building height rises as the floor area increases. It is essential, when sizing the individual areas within the storage system, that the total floor area of the building is selected with regard to the requirement for racking equipment, ramp areas and loading zones. Over and above guaranteeing an optimum building volume, this also means that shorter transport distances can be achieved by linking the core of the warehouse, the ramp area and the loading zone and thus the energy requirement is also lower during operation due to the shorter journeys performed by the transport equipment.

The issue of energy efficiency no longer merely plays a key role in terms of internal company logistics but should be viewed overall. The energy-efficient design of a storage system means taking into consideration a host of subsequent operating characteristics, even at the planning stage. Alongside the use of specific materials, racking types and operating technology, the sizing of the entire system also plays a key role.

Flow storage systems lead to higher space utilization and reduce the energy required for heating, cooling and lighting. What is more, the investment capital for the building and equipment is also lower. Alongside lower energy requirements, savings can also be made in terms of staff costs linked to the shorter transport distances within the warehouse system.

Conclusion

Flow storage systems have logistics-based and efficiency benefits compared with single location racking when the overall costs are taken into consideration. Flow storage systems should always be involved in the decision-making process when dealing with medium to fast-moving pallets and where there is a significant lane capacity.

Flow storage systems offer both environmental and economical benefits for energy-intensive warehousing facilities, for instance the storage of fresh and frozen products. These benefits have led to reputable companies in all sectors opting for flow storage systems to solve their logistics problems.

The performance data and graphs in this document underpin their decision to opt for this storage method. The department specializing in the Planning and Control of Storage and Transport Systems at the Leibniz Universität Hannover is currently developing a software tool to obtain case-specific results, which will offer the possibility of providing project-specific data that can be optimised according to various target variables. Results relevant to the design, such as investment, overall costs and space requirement, will be made available immediately and accurately.

Total improved cost, Reach truck, 5000 LUs, 150 LUs/h, Normal temperature

	Figures as a %	
	Single location rack	Flow storage
Investment	100	117
Total cost	100	81
Energy costs	100	60
Floor area	100	84
Volume	100	55
Staff costs	100	60

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Sponsor

This white paper is the result of the first stage of our research project, in which we are calculating performance data from distribution centres for medium and fast-moving products.

The white paper was produced under the directorship of the Leibniz Universität Hannover (D) with Prof. Dr. Ing. habil. Lothar Schulze from the Planning and Control of Storage and Transport Systems (PSLT) Department as Research Director and the cooperation of Southeast University Nanjing, with Prof. Dr. Ing. Lindu Zhao from the Institute of Systems Engineering as his partner in the Chinese market. In addition, a number of international logistics experts and users have also been surveyed to improve practical relevance and verify the facts.

A simulation tool will be developed in the next stage to evaluate key indicators, such as throughput, number of staff, operating and energy costs etc., to provide reliable forecasts relating to energy balance, optimisation options, overall operating costs and investment payback period.

Interroll hopes to offer the designers and operators of distribution centers worldwide crucial added value with the publication of this white paper and development of the project simulation tool.

Interroll is one of the world's leading manufacturers of key products for internal logistics. Interroll products are primarily used in food processing, airport logistics, courier/express delivery/postal services, distribution centres and various other branches of industry. With its headquarters in Sant'Antonino, Switzerland, the exchange-listed company employs some 1,500 people at 29 locations around the globe serving 23,000 customers.

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Item	Quantity	Status
Item 1	100	OK
Item 2	200	OK
Item 3	300	OK
Item 4	400	OK
Item 5	500	OK
Item 6	600	OK
Item 7	700	OK
Item 8	800	OK
Item 9	900	OK
Item 10	1000	OK



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