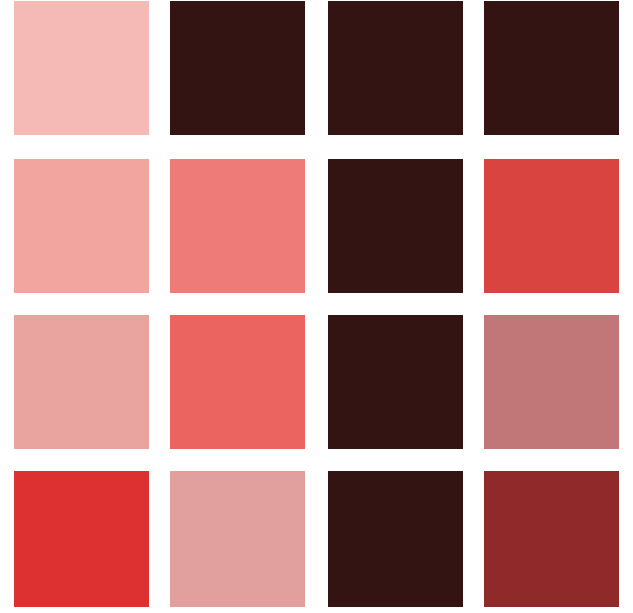




INDUSTRY REPORT · ISSUE 2 · OCTOBER 2026 · TECHNICAL REPORT

Efficiency and Quality in **Central Raw Material** Conveying Systems

Velocity, line design, the choice between machine-side and central, and the effect of the raw material chain on part quality — with sourced figures and clearly stated data gaps.

EXECUTIVE SUMMARY

In central conveying, velocity sets efficiency and a closed chain sets quality

15–20 m/s

Pickup-point air velocity band for pellets; below it the line plugs, above it the line wears

~6 times

Wear when velocity doubles (rises with the 2.5th power of velocity or more)

2 times

Increase in in-line air velocity at a vacuum of only 0.5 bar

10 times

Cost of compressed air at the point of use relative to the equivalent electricity

In a plastic injection molding plant, the path raw material follows from storage to the machine feed throat determines energy and labor as well as part quality. On the efficiency side, the performance of a central conveying system depends less on the size of the pump than on **setting the air velocity at the pickup point in the right band (about 15–20 m/s for pellets)**, on reducing the bends and hoses that inflate the line's equivalent length, and on closing the system's invisible leaks. If velocity falls below this band, the line plugs; if it rises above it, wear increases with roughly the 2.5th power of velocity, bends generate angel hair and dust, filters load up, and the pump conveys more air rather than more material.

Because air expands under vacuum, velocity rises on its own along the line; a vacuum of only 0.5 bar doubles the velocity at the end of the line, which is why a pump upsized "so that it is enough at the end of the line" is the most expensive mistake in the system. On the energy side, the lever with the strongest independent support is not to convey with compressed air; a pump type suited to the distance, speed control and pump staging follow it. For kWh per ton conveyed, **no independent, measured industry benchmark has been published**, and nearly all of the savings percentages in circulation are manufacturer claims.

On the quality side, what is decisive is not a single piece of equipment but **the closedness of the chain**: resin producers give residual moisture limits in their datasheets (PA66: 0.2%, TPU: 0.05%, PBT: 0.04%), some explicitly require the machine to be fed by a closed conveying system and show that dried pellets return to the threshold on a scale of minutes; fines and poor regrind produce unmelted pellets and specks, and a dosing error on the order of a gram in low-ratio masterbatch produces color deviation.

The choice between the machine-side self-contained loader, known on the shop floor as "side pulling", and the central system lies where these two axes intersect: the figures for the central system's energy and scrap advantages are manufacturer claims, and there is no independent measurement comparing the two; the defensible advantages are closed and dry conveying, prevention of wrong material, removal of octabins and forklifts from the production area, and concentration of maintenance at a single point.

In the only published quantitative payback case, too, the main item in the justification is not energy but the elimination of one material handler per shift and of the scrap arising from wrong material, contamination and faulty drying.

This report establishes these relationships with sourced figures, shows the data gaps openly, and proposes a checklist, an error table and a measurement set that can be used directly for design and operation.

0.2% · 0.05% · 0.04%

Residual moisture limit given in the resin producer's datasheet for PA66, TPU and PBT

30 minutes

Practical time in industry articles for processing dried polymer

14–16 months

Expected payback in the only published quantitative case (\$250,000 investment; customer and supplier claim)

Editorial note. The source of every figure is given inline. Statements by equipment manufacturers about their own products or systems are marked as "manufacturer's claim". All web sources were opened on 30 September 2026 and the relevant statement was searched for in the source text; pages whose live address would not open were read from their web.archive.org copy and marked "archived copy"; statements that could not be found in their source were removed from the report. The sources of the figures in the executive summary are given in the relevant sections. Examples derived from source data for this report are marked "Teknik Part calculation"; these are not measurements but illustrations of method; interpretations drawn from the sources are marked "Teknik Part inference" or "Teknik Part interpretation", and field knowledge not based on measurement is marked "Teknik Part field observation".

Scope: the report covers the central conveying axis along which raw material passes from storage to the machine feed throat (conveying, drying, dosing and blending, regrind, metal separation, coding and wrong-material prevention) and assesses part quality through this chain; mold temperature control (conditioning) and cooling and chiller systems are outside the scope and are the subject of a separate report. Inch-pound units are given as in the source, with the SI equivalent added in parentheses (1 ft/min = 0.00508 m/s; 1 mph = 0.447 m/s; 1 inHg ≈ 33.9 mbar).

1 · VELOCITY

Pickup velocity 15–20 m/s: below it the line plugs, above it the line wears

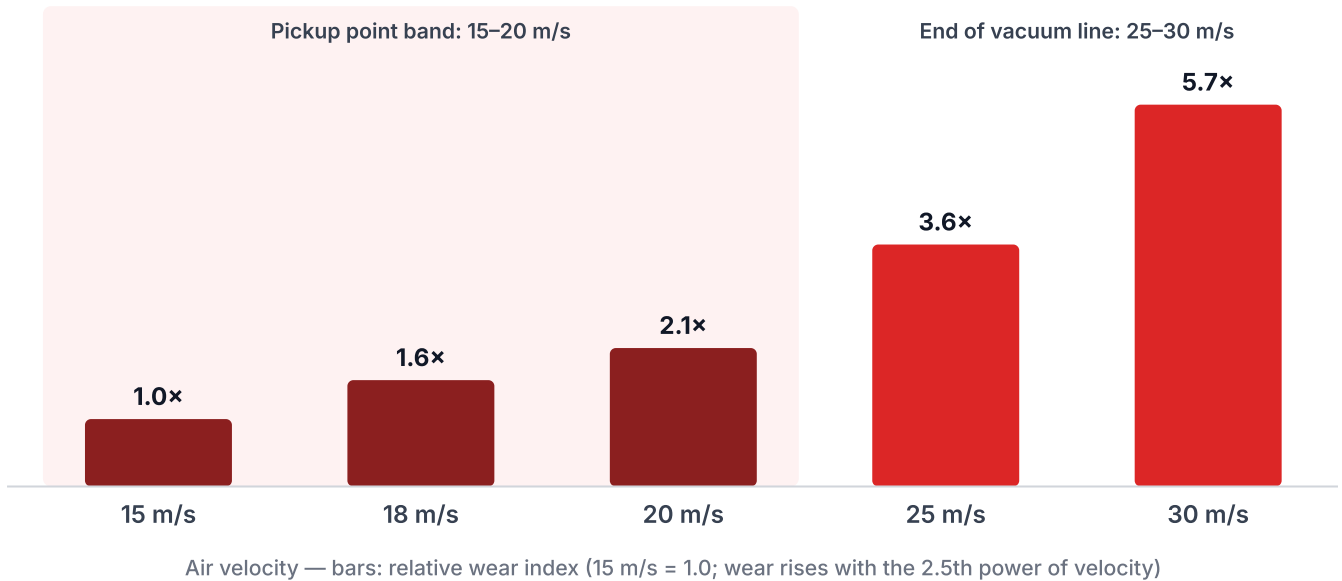
Central conveying in injection molding plants is in practice **dilute-phase** conveying: the pellets are carried in suspension in the air stream. In dilute phase the solids-to-air loading ratio typically reaches up to 15 kg of solids per kg of air; even in dense-phase (plug flow) conveying of pellets the ratio rarely exceeds 30 (Powder & Bulk Solids, D. Mills^[1]). The decisive quantity is the air velocity at the point where the material is picked up into the line. Industry publications give a pickup velocity of **about 3,000–4,000 ft/min ($\approx 15\text{--}20\text{ m/s}$)** for most plastics; for PE (bulk density $\approx 560\text{ kg/m}^3$) about 3,000 ft/min ($\approx 15\text{ m/s}$) is recommended, and for PET ($\approx 880\text{ kg/m}^3$) about 3,500 ft/min ($\approx 18\text{ m/s}$) (Plastics Technology, Put the Oomph Back in Your Vacuum System^[2]). In the same magazine an equipment manufacturer's engineer gives the acceptable band as **35–45 mph ($\approx 15.6\text{--}20.1\text{ m/s}$)**, with 35 mph as the minimum for most pellets (Plastics Technology, Put the Brakes on Resin Conveying Speed^[3]). An independent engineering source likewise gives a starting velocity of about 2,500 ft/min ($\approx 12.7\text{ m/s}$) and an end-of-line velocity of 6,000 ft/min ($\approx 30\text{ m/s}$) for a typical low-pressure (positive-pressure) system with a rotary valve (Blower & Vacuum Best Practices, H. Van Ormer^[4]).

The field's standard reference book gives the same framework. According to David Mills, in dilute phase the air velocity at the line inlet is around **12 m/s for fine powder and about 16 m/s for fine granular material**, and these values are velocities at the *inlet* of the line (Mills, *Pneumatic Conveying Design Guide*, 2nd ed., Elsevier/Butterworth-Heinemann, 2004, p. 6^[5]); the operating range of dilute phase lies between a minimum of about 15 m/s and a maximum of about 30 m/s (Mills, 2004, p. 185^[5]). In the book's experiment with roughly 4 mm PE pellets (50 m line, 53 mm bore, nine 90° bends, with a pressurized blow tank), the minimum velocity for dilute phase was found to be **about 15 m/s**; the same pellets could also be conveyed in low-velocity dense phase down to 3 m/s, but the flow rate remained so low that the author does not consider it economical (Mills, 2004, pp. 269–270 and 292–293^[5]). Mills shows that even a small error in the calculation is dangerous: if the calculation uses 101.6 mm rather than the actual bore of 106.1 mm, velocity drops by about 9% ($16 \rightarrow 14.6\text{ m/s}$) and the line can plug (Mills, 2004, p. 104^[5]); he recommends **a safety margin of about 20%** on the line inlet velocity (Powder & Bulk Solids, D. Mills^[1]; Mills, 2004, p. 359^[5]).

The other face of velocity is wear, and the relationship is not linear. According to an independent engineering source, abrasive wear increases with **the 2.5th power of velocity or more**; if velocity doubles, wear increases about sixfold (Chemical Engineering, Rules of Thumb for Pneumatic Conveying Pipelines^[6]). A manufacturer translates this to the field: with every +10 mph ($\approx +4.5\text{ m/s}$) increase in air velocity, bend service life is roughly halved, and, relative to a 45 mph base, streamer production rises with every +10 mph by about 55% (manufacturer's claim, Plastics Technology, Put the Brakes...^[3]). The

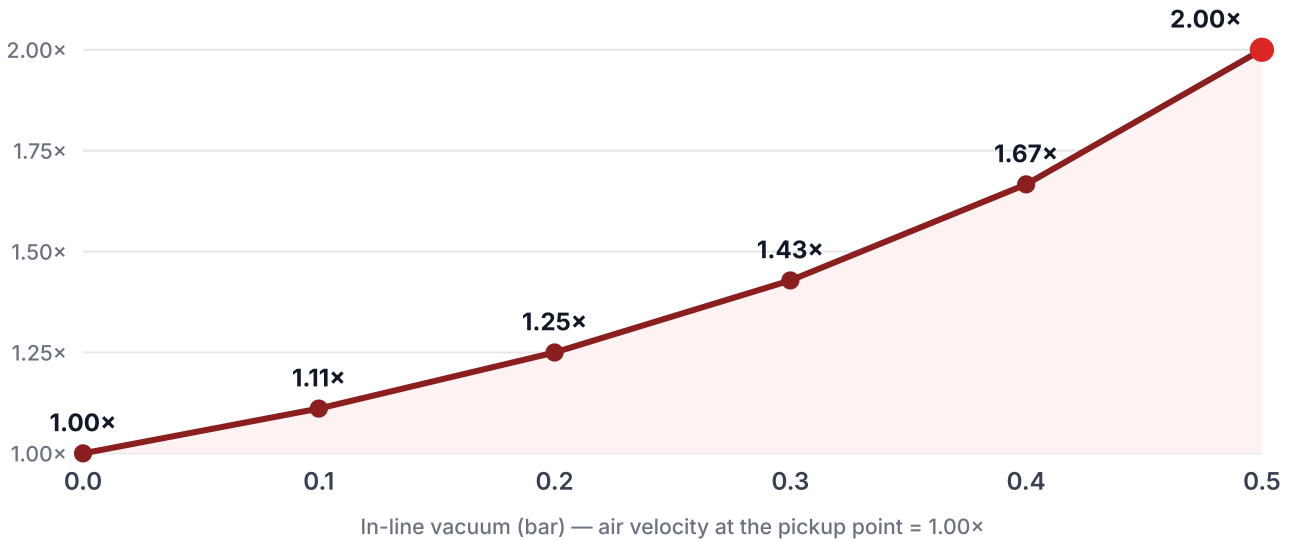
two sources support each other: a velocity increase from 35 to 45 mph, about 29%, means, under the 2.5-exponent rule, about 1.9 times the wear (Teknik Part calculation). Mills also writes that both wear and material degradation increase **exponentially** with velocity (Mills, 2004, p. 428^[5]).

Figure 1 Pickup velocity window and relative wear as a function of velocity (15 m/s = 1.0)



Teknik Part calculation: index derived from the rule that wear rises with the 2.5th power of velocity^[6], it is not a measurement. Pickup velocity band 15–20 m/s^[2,3], end of vacuum line 25–30 m/s^[7]. When velocity doubles the index is ≈ 5.7 (about sixfold in the source's wording).

The particular trap of vacuum systems is that velocity does not stay constant along the line. Because air expands under vacuum, **at a vacuum of only 0.5 bar the air velocity in the line doubles**; for this reason Mills considers stepped lines (whose bore increases along the line) "worth considering" in vacuum systems and anticipates gains in wear, degradation and performance (Mills, 2004, p. 481^[5]). Industry publications likewise give an ideal average velocity of about 4,000 ft/min (≈ 20 m/s) for PE/PP, and 5,000–6,000 ft/min (≈ 25 –30 m/s) at the end of the vacuum line (Plastics Technology, Avoid Those Devilish 'Angel Hairs'^[7]). The practical conclusion is clear: the setting is made for the pickup point. A line set to 15–18 m/s at the pickup point already reaches 25–30 m/s at its end; a pump upsized "so that it is enough at the end of the line" produces unnecessary wear and angel hair in the last bends and at the loader inlet (Teknik Part interpretation, from Mills 2004^[5] and Plastics Technology data). One manufacturer claims "50% or more" throughput from running at low velocity under high vacuum with a dual-diameter (stepped) line, and a reduction of up to 30% in system air velocity with controlled air bleed (manufacturer's claim, Plastics Technology, Put the Brakes...^[3]).

Figure 2 Air expands under vacuum: air velocity multiplier along the line

Teknik Part calculation: at constant temperature air velocity is inversely proportional to absolute pressure (multiplier = $1 \div (1 - \text{vacuum})$); atmospheric pressure is assumed to be 1 bar. The doubling of velocity at 0.5 bar vacuum is given in Mills 2004, p. 481^[5].

Low-bulk-density material makes this balance harder. According to data from a manufacturer's engineer on recycled PET, the loading ratio is at most 5:1 for flake and up to 15:1 for chip; equipment that conveys 10,000 lb of chip per hour carries only 4,000 lb of flake, and a system that conveys chip in 3-inch pipe at 6,000 lb/h requires 3½-inch pipe for flake (Plastics Technology, Looking to Handle More rPET?^[8]).

Injection molding regrind is not rPET flake; but these data are a strong signal that the same line will carry noticeably less regrind than pellets, and that regrind must be accounted for separately when choosing the line diameter. No specific published pickup velocity value for injection molding regrind could be found.

2 · LINE GEOMETRY

Bends, vertical runs and hose determine the line's true length

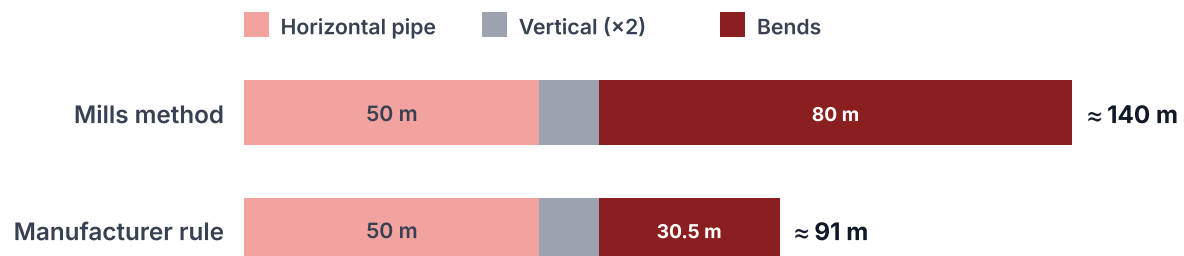
The pump sees not the line's length in meters but its **equivalent length**. Under one manufacturer's rule, 1 ft of horizontal run counts as 1 ft, 1 ft of vertical run as 2 ft, a 90° bend as 20 ft (≈ 6.1 m) and 1 ft of flexible hose as 3 ft; the pump is selected from the pump curve using the equivalent distance and the required throughput (manufacturer's claim, Novatec: System Vacuum Pumps^[9]). Another manufacturer likewise advises calculating the equivalent distance rather than the physical distance when selecting a pump (manufacturer's claim, Conair: 12 Do's and Don'ts^[10], archived copy). As will be seen below, the

bend equivalent varies markedly from source to source; there is therefore no single "correct" equivalent length, and the rule by which the pump curve in use was prepared must be obtained from the manufacturer.

The bend equivalent is the most widely scattered value among the sources, because it depends on velocity. In rough-estimate sources a 90° bend counts as 5 m of straight pipe, in another textbook as 7.5 m, and neither is recommended for detailed design (powderprocess.net, Pipe equivalent length^[11]). In the average of Mills' barite and cement measurements, the equivalent length per bend in low-velocity dense phase at 4 m/s is only **about 2 m**, but in dilute phase at 15 m/s it rises to **about 16 m** (Mills, 2004, p. 336^[5]); a measurement with wheat flour found at 16 m/s a loss of about 130 mbar per bend, i.e. about 23 m of equivalent length (Mills, 2004, p. 338^[5]), and the book's own barite measurements show a range of 50–170 mbar per bend (Mills, 2004, pp. 256 and 333^[5]). These values are derived from powders and fine-grained materials (barite, cement, flour); the book gives no separate bend equivalent for plastic pellets, and this difference must be kept in mind when the values are transferred directly to pellets. Mills' equivalent-length formula is $Le = h + 2v + N \cdot b$; vertical upward sections are multiplied by two, and this factor is applied "universally" to dilute and dense phase (Mills, 2004, p. 390^[5]).

This means that in a typical in-plant line, bends can be as decisive as distance. A line with 50 m horizontal, 5 m vertical and five 90° bends, operating at 15–16 m/s, comes to $Le \approx 50 + 2 \times 5 + 5 \times 16 \approx \mathbf{140\ m}$ by Mills' method; by the manufacturer's rule (bend 6.1 m) the same line comes to about 91 m (Teknik Part calculation). Both calculations show that bends account for between one third and more than half of the equivalent length (Teknik Part calculation; Mills' bend value is derived from powders). On the measurement side, one data point shows the effect of increasing the diameter: in a 2-inch (~50 mm) vacuum line, 100 ft (~30 m) of line consumes about 1 inHg (~34 mbar) and 300 ft (~91 m) about 3 inHg (~100 mbar); moving to a 3-inch (~76 mm) diameter reduces this pressure loss by **about 50%** (Plastics Technology, Put the Oomph Back...^[2]). Another manufacturer writes that air alone, in a 2-inch line, creates a drop over 100 ft of about 0.75 inHg, that the "usable vacuum" left to convey material is the pump vacuum minus the air loss, and that in a 1,000 ft line only 2.5 inHg remains with a standard positive-displacement pump (manufacturer's claim, Novatec: Overcoming Long Conveying Distances^[12]).

Figure 3 Equivalent length of the same line under two rules (50 m horizontal, 5 m vertical, five 90° bends)



Teknik Part calculation. Mills method: $Le = h + 2v + N \cdot b$, bend $\approx 16\ m$ (15 m/s, value derived from powders)^[5]. Manufacturer rule: vertical $\times 2$, 90° bend 20 ft $\approx 6.1\ m$ (manufacturer's claim)^[9].

Bend geometry, by contrast, is decisive less for energy than for wear and dust. According to Mills, the bend equivalent length depends little on geometry for D/d ratios between about **4 and 40**; it is much larger for very short-radius bends and especially for blind tees (Mills, 2004, p. 390^[5]). An independent engineering source states that long-radius bends with $R/D = 8-10$ give lower pressure loss and that solids velocity drops by 5–50% within a bend, and recommends leaving at least 20 ft (~6 m) of straight horizontal line after the material feed point for acceleration (Chemical Engineering, Rules of Thumb^[6]). A resin producer's polyolefin guide recommends keeping bends between 5 and 10 D and states that sliding and streamer formation increase above 10 D (INEOS: Fines, Angel Hair and Streamers^[13]). Read together, the two findings lead to the conclusion that the real gain from a large radius lies not in pressure loss but in wear and material degradation, but that increasing the radius without limit also lengthens frictional contact for soft pellets (Teknik Part interpretation). Because bends placed back to back cause material to drop out of the air stream, leaving straight pipe between them is recommended; the ideal line is described as "a single straight pipe with no bolted couplings, diverters, bends or flexible hose" (Plastics Technology, Follow These Steps to More Efficient Central Pneumatic Conveying^[14]).

No sourced fixed ratio could be found for flexible hose, but the direction is clear. In Mills' tests with cement and barite (53 mm, 40 m test line), rubber hose is not much different from pipe in low-velocity dense phase; as velocity increases, the pressure loss in hose rises markedly, because particles rebound little from the hose wall and must be re-accelerated; on the other hand, thanks to its flexibility, hose has an advantage against erosion and particle degradation (Mills, 2004, pp. 114–115^[5]). One manufacturer gives machine-side loader throughputs for a 15 ft (4.5 m) flexible hose condition, and states explicitly that at most 30 ft (9 m) of horizontal pipe and one bend can be added and that additional vertical runs, bends or hose will reduce the recommended throughput (manufacturer's claim, Novatec VLP Data Sheet^[15]; the VLP is a loader designed for powder and dusty regrind). Excess hose and coiled loops at coupling stations should be reduced (Plastics Technology, Follow These Steps...^[14]).

3 · DUST, WEAR AND LEAKAGE

Angel hair, wear and leakage are losses the system creates itself

Angel hair, streamers and fines do not come from outside; the conveying system produces them itself. A resin producer sets out the definitions clearly: fines arise when pellets are torn on rough surfaces at high velocity; streamers from frictional heat during prolonged contact with smooth surfaces (long-radius bends); angel hair from brief contact; and these then fall into silos and machine hoppers (INEOS^[13]). The same source recommends keeping velocity in polyolefin dilute-phase conveying comfortably above the saltation velocity but **at most about 5,500 ft/min (~28 m/s)**, increasing the diameter by one step in the last third of long lines (e.g. 3→4 inches), keeping the conveying air preferably at 90–100 °F and at most 130 °F (~54 °C), and using roughened (shot-peened or sandblasted) pipe; these values are for pressure

systems on the scale of silo transfer (INEOS^[13]). Mills writes that nylon, PE and polyester pellets are prone to melting in suspension conveying, and that a roughened pipe surface reduces the problem "significantly" by preventing sliding (Mills, 2004, p. 52^[5]). Roughened pipe is expected to last at least a year before it needs reworking (Chemical Engineering, Rules of Thumb^[6]). According to one manufacturer, a standard bend produces as many streamers as 100 ft of horizontal pipe (manufacturer's claim, Plastics Technology, Convey Pellets Around Corners...^[16]).

The order of measures should be read together with their cost. In industry articles the first step is to adjust the solids-to-air ratio with an air bleed-off valve, at a cost given as \$0–200; excess air rubs the pellets against the wall and produces streamers. In systems where pressure blowers heat the air to 100–200 °F, an air-to-air heat exchanger costs \$10,000–25,000, and the last resort is switching to dense phase (Plastics Technology, Six Tips to Prevent Those Annoying Streamers^[17]). In pressure systems the air temperature rises by 12–14 °F per psi (Plastics Technology, Avoid Those Devilish 'Angel Hairs'^[7]); in the vacuum lines of injection molding plants this heating is more limited, and there the dominant cause of angel hair is velocity and bend friction (Teknik Part interpretation). For an injection molding plant the order of priority is therefore velocity control, then bend type and surface, and finally a dust and streamer separator at the point of use. Manufacturers state that dedusters working on the air-wash principle can be mounted at the point of use, between the loader and the machine hopper (manufacturer's claim, Piovani: DeDuster^[18]).

For glass-fiber and mineral-filled materials, too, the first and cheapest measure is velocity; the choice of bend material comes after velocity optimization. One manufacturer claims that, in bends designed for 40% glass-filled nylon, surface hardening raised the hardness of 304 stainless from 29 to 65 HRC and that, unlike ceramic/enamel coatings, the hardened surface does not flake off and damage downstream equipment (manufacturer's claim, Plastics Technology, Conveying Elbows Handle 40% Glass-Filled Nylon^[19]). Ceramic-lined bends are also offered for abrasive material (manufacturer's claim, US Systems, Ceramic-Backed Elbows^[20]). Borosilicate glass bends are offered in a pipe manufacturer's catalog with a bonded copper strip for conductivity; that the wear-resistant version lasts "significantly longer" than 1.4301 stainless is claimed without a numerical ratio (manufacturer's claim, Michel Tube Turkish product catalog 2025, pp. 10–11^[21]). No independent measurement comparing stainless, hardened, glass and ceramic bends in mm/year or in wear per ton could be found.

In regrind, part of the dust generation comes from how the line is assembled. A resin producer asks that pipe couplings be checked first in regrind systems: a misaligned pipe forms a sharp step that tears fines off the particles; chamfering the downstream sides is recommended (INEOS^[13]). A pipe manufacturer likewise emphasizes the flattened inner seam of its stainless pipes and its "wrinkle-free" bent elbows (Michel Tube Turkish product catalog 2025, pp. 9–11^[21]).

Leakage is the most insidious loss in a vacuum system. Mills' warning is clear: in vacuum systems, air leaking in cannot be seen and may not be heard over factory noise; it can starve the line inlet of air and lead to plugging (Mills, 2004, pp. 61 and 481^[5]). Industry sources write that leaks typically occur at

flexible hose, couplings, gaskets and valves, that the system "sucks air instead of material", and that leaks can be found by visual inspection or a smoke test (Plastics Technology, How to Set Up & Maintain an Efficient Resin Handling System^[22]). An equipment manufacturer's operating manual makes the mechanism concrete: if more than one loader is connected to the same line, the check valve of the idle loader must close vacuum-tight; if it does not, a vacuum leak occurs at the other loaders and they "lose material conveying capacity" (Ferlin MOVAC microprocessor control manual V1.00, p. 14^[23]); the manual requires the loader seals (v-rings and the rubber under the lid) to be checked monthly and the vacuum valve yearly (same manual, p. 12). No source could be found that gives the quantitative effect of uncontrolled leakage as kWh/ton or as throughput loss.

Controlled leakage, by contrast, is a deliberate tool and must not be confused with uncontrolled leakage. In suction lances, the secondary air taken in through the upper holes is adjustable and important for correct operation (manufacturer's claim, Doteco: Suction lances^[24], archived copy; the product page is no longer online); flow limiters allow several receivers to be loaded simultaneously with one large pump; otherwise an "open" line drops the vacuum or, when a single receiver is loading, velocity rises too far and damages the material (US Patent 10179708^[25]).

4 · PUMP AND ENERGY

Pump type is chosen by distance, energy by demand

Four mechanical vacuum sources are used in conveying plastic pellets, and each has a natural operating zone. Industry articles state that a single-stage side-channel (regenerative) blower can reach about 8 inHg (~270 mbar), a two-stage one 10–12 inHg (~340–410 mbar), and a positive-displacement (lobe) blower 14–16 inHg (~475–540 mbar), though most are sized for 12 inHg (~405 mbar); a claw pump operates up to 22 inHg (~745 mbar) and is suited to equivalent distances of 1,000 ft (~305 m) and more (Plastics Technology, Put the Oomph Back...^[2]). One manufacturer specifies the single-stage regenerative pump for 6.5–8.5 inHg and lines of at most 2.5 inches, and the standard positive-displacement pump for 11–12 inHg and lines of up to 4 inches (manufacturer's claim, Novatec: Overcoming Long Conveying Distances^[12]). According to a pump manufacturer, the side-channel blower is high-flow, oil-free and relatively inexpensive, but its flow drops as the load increases; the roots blower is contact-free and oil-free but limited to a differential pressure of 500 mbar; the rotary vane pump gives the deepest vacuum but is oil-lubricated and needs regular maintenance; the claw pump provides deep vacuum with oil-free, contact-free compression (manufacturer's claim, Busch, Vacuum Pumps for Pneumatic Suction Conveying^[26]). Mills also writes that the pressure ratio of a positive-displacement blower is limited to about 2, so that in vacuum duty it can only reach about 0.5 bar (Mills, 2004, p. 54^[5]).

Figure 4 Vacuum attainable by pump type (mbar)

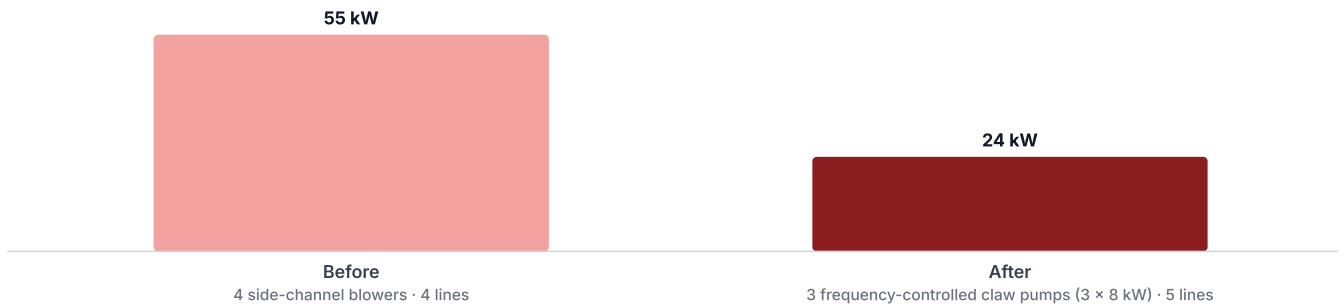
Source: Plastics Technology^[2]. Bars show the upper end of the range. Most positive-displacement pumps are sized for 12 inHg (~405 mbar); a claw pump is suited to equivalent distances of 1,000 ft (~305 m) and more.

Mills' second important warning concerns rating: a vacuum pump is rated not on free air but on **the volumetric flow at the pump inlet**; the line inlet velocity must therefore be calculated separately according to the vacuum level (Mills, 2004, p. 481^[5]). For Turkey, a correction must be added to this. According to industry sources, systems deliver, **at 50 Hz or at high altitude, about 17% less capacity** (Plastics Technology, How to Set Up & Maintain an Efficient Resin Handling System^[22]). The 50/60 Hz ratio is about 0.83, consistent with this drop; a designer sizing a system in Turkey from a pump curve published for 60 Hz can bring the line inlet velocity down to the plugging limit if no frequency correction is made (Teknik Part interpretation). The same source gives a rough match between pump power and line diameter: for a 5 hp pump a 1.75–2-inch outside-diameter line, for 15 hp 3 inches, for 25 hp 4 inches (Plastics Technology, How to Set Up...^[22]).

For kWh per ton conveyed there is **no** reliable industry benchmark. An independent government guide shows "materials handling" as a separate item in the typical energy breakdown of plastics processing plants but gives no percentage (UK Good Practice Guide 292, Energy in plastics processing^[27]); an industry association's energy management guide likewise recommends running conveying systems "on demand" and making use of gravity where possible, without giving conveying a numerical share (the guide's recommendation of variable-frequency drives for vacuum pumps applies to vacuum calibration tanks in profile extrusion) (BPF/Tangram, Energy Management in Plastics Processing^[28]). In the same vein, a trade magazine series (R. Kent, 2006) writes that only 5–10% of the energy consumed in injection molding goes into the polymer, with the remaining 90–95% spent running the machine, and recommends running conveying systems "on demand" by linking them to machine operation; it gives no percentage for conveying's share of plant energy (PlasticsToday, Part 3: Reducing energy costs^[29], archived copy). To get an order-of-magnitude idea, the method is as follows: the pump's hourly energy is divided by the tonnage conveyed. For example, if a 5.5 kW pump conveys 1,500 kg per hour and runs continuously, this comes to about 3.7 kWh/t; if it runs on demand and is under load 35% of the time, about 1.3 kWh/t (Teknik Part calculation; hypothetical values, not measurements). The real message of this calculation is not a single number but the fact that the duty cycle directly determines kWh/t.

The principle in energy saving with the strongest, independent support is **not to convey with compressed air**. The government guide writes that compressed air at the point of use is **ten times** more expensive than equivalent electricity, that savings of up to 30% can be achieved with simple, inexpensive good-housekeeping measures, and gives an explicit action item: "Do not use compressed air to convey granules or product" (GPG 292, Section 4.3^[27]). By an industry rule of thumb, at 80 psig about 1 bhp produces only 4 scfm (≈ 0.75 kW for ≈ 6.8 m³/h) (Plastics Technology, Follow These Steps...^[14]). In an independent consultant's assessment of a pressure (positive-pressure) conveying system, it was calculated that if the conveying line could be operated with a 55–60 psia main air supply, there would be an average reduction of 112 kW at the primary compressed air input, which at 8,500 h/year and \$0.10/kWh would save about \$95,200/year (a projection; no post-implementation measurement is given); the author always recommends an electric-motor-driven central vacuum pump for energy efficiency (Blower & Vacuum Best Practices, Van Ormer^[4]). This case is from a general bulk materials plant and is not specific to plastic injection molding. The government guide also notes that conveying systems can use a great deal of energy even when they are conveying no product, and recommends systems that run on demand (GPG 292^[27]).

All the available figures for pump replacement and speed control come from manufacturer cases. In one pump manufacturer's case, four side-channel blowers totaling 55 kW that fed four extrusion lines were replaced first by two claw pumps which, at 50 Hz, are rated 8 kW each and, when a fifth line was added, by a third frequency-controlled claw pump (the material conveyed was flexible PVC); the first pump starts at 500 mbar and the additional pumps at 700 mbar absolute pressure, and a 1,000 L buffer volume is used; the plant consumed 160,000 kWh less than in the previous year; the case is headlined "up to 70% energy savings", but the text contains no calculation of this figure (manufacturer's claim, Busch, Up to 70 percent energy savings^[30]). Installed power fell from 55 kW to 24 kW, i.e. by about 56%; it should also be borne in mind that in this comparison the new side feeds five lines (Teknik Part calculation). The case is from extrusion and should not be transferred directly to injection molding. Another manufacturer claims that its multistage regenerative pump (a variable-frequency drive is optional), compared with a similarly sized positive-displacement pump at equal throughput, delivers energy savings of up to 50% with its own low-velocity conveying method and up to 25% in standard operation (manufacturer's claim, Plastics Technology, Conveying: Pump is Quiet, Powerful, Energy-Efficient^[31]); the same manufacturer's valve unit carries a claim of up to 70% shorter fill time in one application (manufacturer's claim, Plastics Machinery & Manufacturing^[32]). The first pump manufacturer claims energy savings of up to 50% for its variable-speed-drive pump compared with a fixed-speed vacuum pump (manufacturer's claim, Busch Variable Speed Vacuum Pumps^[33], archived copy; the product page is no longer online). The "cube law" specific to centrifugal machines does not apply to positive-displacement pumps such as claw and roots pumps; in these, power falls roughly linearly with speed (Teknik Part interpretation).

Figure 5 Installed power before and after a pump replacement case (kW)

Source: manufacturer's claim^[30]; the drop of about 56% is a Teknik Part calculation. The case is in extrusion (flexible PVC) and should not be transferred directly to injection molding. The plant consumed 160,000 kWh less than in the previous year.

There is a limit to stopping the pump when there is no demand. An equipment manufacturer's control manual states that after the last loader has finished its suction, the pump idles for a set time, drawing false air through the standby valve, and advises that the pump **should not start more than 10 times per hour** (Ferlin MOVAC microprocessor control manual V1.00, p. 7^[23]). Another manufacturer likewise claims that frequent stopping and starting of the pump motor is prevented with an idle valve and timer option (manufacturer's claim, Conair RG Series^[34], archived copy). This trade-off between energy and motor life requires the idle time to be set according to the plant's demand profile. Parallel pump staging and buffer volume soften this trade-off; one manufacturer describes a permanent vacuum system in which several vacuum units switch on and off automatically as required, but gives no figures (manufacturer's claim, Piovan Permanent Vacuum System^[35]).

The filter is a series resistance on the pump's suction side. According to industry sources, filters sit in two places, in the pump's dust collector and at each receiver; a clogged filter reduces capacity as much as excess bends do (Plastics Technology, How to Set Up...^[22]); a large filter with good release properties and the correct pulse setting reduce pressure drop and power consumption (Plastics Technology, Follow These Steps...^[14]). The upward air velocity in the receiver's annular channel is 250–300 ft/min, less than 10% of the pickup velocity (Plastics Technology, Put the Oomph Back...^[2]). One manufacturer's manual states that the central filter is to be used with dusty material, in systems with more than one loader and with pumps of 3 kW and above, that the safety valve protecting the filter housing from collapse is set to 500 mbar, and that filter cleaning should not be switched off (Ferlin MOVAC Central Filter manual, pp. 5–6^[36]); the same manufacturer claims that its bag filters are cleaned by being drawn down to 500 mbar and then "knocked" by a sudden return to atmospheric pressure, which preserves the system's capacity (manufacturer's claim, Ferlin Product Guide, 2024, p. 11^[37]). No source could be found that gives the effect of clean versus dirty filter pressure drop in mbar and kWh. On noise, one manufacturer claims a reduction of at least 12 dB with a double-walled line (manufacturer's claim, motan Central conveying^[38]).

5 · MACHINE-SIDE AND CENTRAL

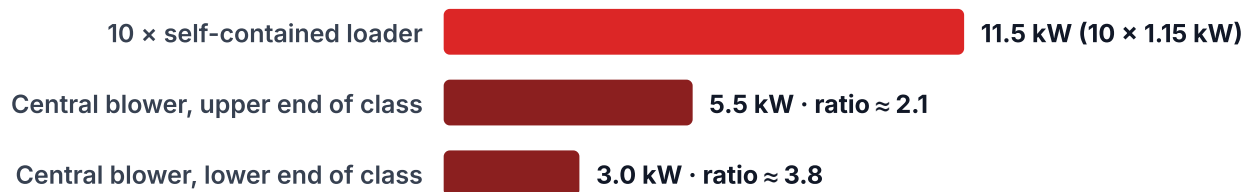
The gain from moving from machine-side loaders to a central system lies more in the chain than in energy

The arrangement known on the shop floor as "side pulling" is **the machine-side self-contained loader**, which draws material with its own motorized loader from an octabin, sack or box standing next to each machine. According to Teknik Part field observation, this is the common arrangement in small and medium-sized plants; no survey or industry data measuring this could be found. According to Teknik Part field observation, most of these loaders use single-phase commutator (carbon brush) motors; in the datasheets reviewed, powers lie in the range of **about 0.46–1.32 kW** and capacities 15–400 kg/h. One manufacturer's series gives 0.46–1.32 kW and 30–400 kg/h, but these capacities are for pellets at 0.65 kg/L and conveying over **4 m vertical + 1 m horizontal** (manufacturer's claim, Shini SAL-U user manual, p. 10^[39]); another manufacturer's brushless single-phase series gives 0.87–1.1 kW and 15–200 kg/h, valid under a condition of **5 m distance and 3 m height** (manufacturer's claim, motan METRO SG brochure, p. 11^[40]). A third manufacturer writes that the self-contained loader conveys material "about 15 ft" (≈ 4.6 m) (manufacturer's claim, Novatec: Self Contained Loader^[41]). The fact that datasheet values are given for 4–5 m is the physical reason why the source container has to stand a meter or two from the machine (Teknik Part inference). Feeding a single machine from a distance, however, does not require a central system: one manufacturer claims that with a separate three-phase side-channel blower (types in the table 1.3–7.5 kW, blower options up to 11 kW), single-machine feeding is possible over a conveying path of **up to 100 m** and is suitable for continuous operation (manufacturer's claim, Koch-Technik Einzelfördergeräte, pp. 3–4^[42]).

The brush of a commutator motor is a consumable part and the main maintenance item of a self-contained loader. One manufacturer writes that brushes need to be replaced at **about 300 operating hours**, and that its own brushless motor lasts 4–5 times longer than a brushed one (manufacturer's claim, sponsored article, Plastics Technology: Which Self-Contained Loader Is Best?^[43]); in another manufacturer's control, the default thresholds of the brush replacement alarm are **800, 900 and 1,000 operating hours** (manufacturer's claim, Shini SAL-U user manual, p. 25^[39]). The two values describe different things (one is a replacement limit, the other an adjustable alarm default); the defensible reading is that brush life lies between **a few hundred and about 1,000 operating hours**. A loader whose motor runs for 30% of machine operating time, on a machine that operates 7,000 hours a year, runs about 2,100 hours a year; this means 2–7 brush replacements per loader per year, or 20–70 service interventions a year in a ten-machine shop (Teknik Part calculation; the 30% duty cycle is an assumption, no sourced value could be found). Brushless and three-phase self-contained types eliminate this item but do not change the other characteristics of the machine-side arrangement.

All the numerical claims on the energy side come from manufacturers. One manufacturer claims, without explaining the calculation method, that a central conveying system uses **about 80% less energy** than self-contained systems attached to the machines (manufacturer's claim, motan METRO G system solutions, p. 17^[44]); another manufacturer describes self-contained loaders as "high energy consumers" (manufacturer's claim, Novatec: Why Utilize a Central Plastics Conveying System^[45]); a third says that the biggest energy benefit comes from installing a central pump and piping system in place of "energy-hungry" small self-contained loaders (manufacturer's claim, Conair, Ways to save energy in plastics processing^[46], archived copy). One manufacturer's claim of savings of up to 50% compared with a single-line system, through pumps working together when needed, is a comparison not with the self-contained loader but between central architectures (manufacturer's claim, motan, Why to use a central vacuum system^[47]). For an order of magnitude, installed power can be compared: ten machines each fed by a 1.15 kW self-contained loader carry 11.5 kW of installed motor power; the total demand of ten machines each consuming 60 kg per hour, about 600 kg/h, on the other hand lies within the capacity range of a single three-phase side-channel blower of the 3–5.5 kW class in the datasheets (Koch-Technik, pp. 3–4^[42]). In this rough comparison the installed power ratio comes out at about 2–4 times ($11.5/5.5 \approx 2.1$; $11.5/3.0 \approx 3.8$) (Teknik Part inference; this is installed power, not consumption, datasheet capacities are for short distances, and the length of the central line reduces capacity). The manufacturer's 80% is above this ratio; the difference may come from assumptions about duty cycle, start-stop and motor efficiency, and cannot be verified. Since conveying's share of plant energy is small in any case, the real gain from this transition lies not in energy but in the items below (Teknik Part inference).

Figure 6 Installed motor power for ten machines: machine-side loaders versus a single central blower (kW)



Teknik Part inference; from manufacturer datasheets^[39,42]. This is installed power, not consumption; it is for a total demand of ~600 kg/h; datasheet capacities are for short distances, and the length of a central line reduces capacity.

On the labor and logistics side, the difference is structural. Because a self-contained loader conveys only a few meters, the source container has to stand in the production area; one manufacturer describes this as a production area clogged with octabins and the forklifts that move them, and writes that a central system takes the material containers out of the production area (manufacturer's claim, Novatec: Why Utilize a Central Plastics Conveying System^[45]); another manufacturer claims that a central system frees up space in the production area for additional machines and eliminates both filter cleaning at the machine and the need to bring raw material to the machine (manufacturer's claim, motan METRO G, p. 17^[44]). The same manufacturer claims **raw material savings of at least 1–2%** in a central system through reduced spillage and contamination (motan METRO G, p. 17^[44]); however, the same figure also appears

in the same manufacturer's brochure for simple machine-mounted loaders, this time as the gain from spill-free automatic loading (manufacturer's claim, motan METRO SG, p. 12^[40]). Most of the 1–2% therefore belongs to the move from manual bucket filling to automatic loading; the remaining scrap gain in moving from an already automatic self-contained loader to a central system is smaller (Teknik Part inference). A container standing open beside the machine carries two further quality risks: dipping the suction lance into the wrong container depends on a single human error, and hygroscopic material is exposed to shop-floor air; resin producers' warnings against leaving dried material in an open hopper are given in the quality section below. In a central system the wrong-material risk moves to the coupling station and can be closed off with coding; on a line connected to the dryer, closed conveying with dry air and line purging are possible, whereas the machine-side self-contained loader offers no such option (manufacturer's claim, motan METRO SG, p. 7^[40]).

There are no measured data for noise and heat. Manufacturers highlight the sound-insulated motor cover as a feature, but none of the datasheets reviewed gives a dB(A) value measured at the machine (motan METRO SG, p. 5^[40]; Shini SAL-U 2022 brochure^[48]); one manufacturer's promotion of its brushless model as "as quiet as a three-phase vacuum unit" indirectly concedes that the brushed motor is noisier (manufacturer's claim, Moretto KASKO Brushless^[49]). The heat side is physics: the electrical power drawn by the motor ultimately passes into the surroundings as heat. Ten 1.15 kW loaders at a 30% duty cycle continuously release about 3.5 kW of heat into the production hall (Teknik Part calculation; the duty cycle is an assumption). When the central pump is housed in a separate room, this source of heat and noise leaves the production hall (Teknik Part inference).

The structural weakness of a central system is the single point of failure: in a self-contained arrangement a motor failure stops a single machine, whereas the failure of a central pump without a standby stops all the machines connected to it (Teknik Part inference). The manufacturers' standard solution is a standby pump that cuts in automatically; one manufacturer claims that in the event of pump failure the control switches to the standby blower without any production stoppage (manufacturer's claim, motan METRO SG, p. 7^[40]). The number of receivers per control is 8 in a small single-station system (same document, pp. 4 and 7–8) and rises to 99 loaders and 8 conveying lines in large systems (manufacturer's claim, motan METRO G, pp. 15–16^[44]); as shown in the next section, this is control capacity, not pump capacity. No source could be found for the switchover time of the standby pump or for the actual availability of a central system.

The only published numerical threshold for the choice belongs to one manufacturer: self-contained loaders are best suited to processors conveying material **for fewer than six machines and over short distances** (manufacturer's claim, Novatec: Ultimate Guide to Self-Contained Loaders^[50]). This is a rule of thumb; distance, the number of materials and the need for central drying are more decisive than the threshold, because the moment a central dryer is installed, conveying is already centralized (Teknik Part interpretation). Nor is the choice binary. One manufacturer presents self-contained and simple solutions as a "first step" toward a later system solution and writes that these units can be integrated into system solutions (manufacturer's claim, motan METRO SG, pp. 2 and 12^[40]); another claims that several devices

can be connected to a common control unit to set up "a small central material conveying system" (manufacturer's claim, Wittmann FEEDMAX basic press release, 2018, p. 2^[51]). A five-step migration path emerges from these product tiers: from manual bucket filling to the machine-side self-contained loader, from there to a small central system with a single station and eight receivers, then to a full central system with coupling stations and a standby pump, and finally to automatic material distribution (Teknik Part inference, derived from manufacturers' product tiers). A hybrid arrangement can also be set up: the main raw material is fed from the central line, while special material for a single machine, masterbatch or regrind is fed by a small machine-mounted loader; no manufacturer statement explicitly recommending this could be found, and the arrangement is derived from existing products (Teknik Part inference). As a historical reference, in 2006 an equipment supplier estimated that about 55% of US molders used central material conveying, and that only 3–5% had centralized both conveying and drying (supplier estimate, Plastics Technology, 2006^[52]).

The basic limitation of this comparison is clear: **no independent measurement comparing the machine-side self-contained loader and the central system in terms of energy, labor, noise, scrap or quality has been published.** The table below brings together the sourced findings and the Teknik Part inferences, each with its own label.

Table 1 Machine-side self-contained loader and central system

Criterion	Machine-side self-contained loader	Central system	Source / basis
Drive	Single-phase motor per machine, mostly commutator type (Teknik Part field observation), ~0.46–1.32 kW; brushless and three-phase types exist	One or several three-phase pumps; can be housed in a separate room	Manufacturer datasheets: Shini ^[39] , motan ^[40]
Distance	Datasheet capacities for 4–5 m; single-machine feeding with a three-phase side-channel blower up to 100 m	Depends on equivalent distance and pump type (pump section)	Novatec ^[41] , Koch ^[42] (manufacturer)
Installed power, 10 machines	~11.5 kW (10 × 1.15 kW)	For the same ~600 kg/h demand, a single blower of the 3–5.5 kW class; ratio ~2–4 times	Teknik Part calculation; Koch datasheet
Energy claim	—	~80% less (method not disclosed)	motan ^[44] (manufacturer)
Maintenance item	Brushes, a few hundred to ~1,000 operating hours; filter at the machine	Pump, central filter, gaskets and valves; at a single point	PT/Novatec ^[43] , Shini ^[39] (manufacturer)
Location of the source container	In the production area, beside the machine; forklift traffic	Warehouse, mezzanine or silo; outside the production area	Novatec ^[45] , motan ^[44] (manufacturer)
Raw material scrap	The 1–2% savings claim for spill-free automatic loading is also made for this arrangement	The same 1–2% claim; the additional gain over the self-contained loader is smaller	motan SG, p. 12 ^[40] , motan G, p. 17 ^[44] (manufacturer); Teknik Part inference
Wrong material	Dipping the lance into the wrong container depends on a single human error	Color, RFID or automatic coding at the coupling station	Teknik Part inference; motan and Wittmann (manufacturer, architecture section)

Criterion	Machine-side self-contained loader	Central system	Source / basis
Hygroscopic material	Open container, shop-floor air; no conveying with dry air	Closed conveying with dry air and line purging possible	motan ^[40] (manufacturer); DuPont, Covestro (quality section)
Noise	No measured dB(A); motor at the machine	No measured dB(A); pump can be moved outside the hall	Manufacturer datasheets; Teknik Part inference
Heat released into the hall	~3.5 kW continuous (10 × 1.15 kW, 30% duty)	Outside the hall if the pump is in a separate room	Teknik Part calculation
Effect of a failure	Only that machine stops	Without a standby pump, all connected machines stop; a standby pump can cut in automatically	motan ^[40] (manufacturer); Teknik Part inference
Scaling	A new loader for each new machine	Receivers are added up to pump and control capacity	motan, Wittmann ^[51] (manufacturer)
Suitable application	Fewer than six machines, short distance	Many machines, long distance, central drying, many materials	Novatec ^[50] (manufacturer); Teknik Part interpretation

6 · ARCHITECTURE AND SIZING

A central architecture is sized for peak demand and resource sharing

A typical central chain runs from storage (silo, octabin, container, dryer hopper) to a suction lance or pickup box, from there to a coupling or distribution station, the material line and selector valves, the vacuum receivers on the machines, the vacuum line, the filter and the pump; a central control sequences all of them. The sequencing valve determines when each receiver draws material, and the receivers draw in turn so as not to overload the system (manufacturer's claim, Novatec: Ultimate Guide to Vacuum Receivers^[53]); the central control is programmed to monitor all receivers and blowers so as to keep the machine hoppers full (US Patent 10179708^[25]). Receiver volumes typically lie in the range of 0.1–6 ft³ (≈3–170 L) (Plastics Technology, Follow These Steps...^[14]); one manufacturer's loader series covers hopper volumes of 1–40 L (Ferlin MOVAC microprocessor control manual V1.00, p. 13^[23]). For regrind and irregular material, a larger discharge diameter or a bridge breaker may be needed at the receiver (manufacturer's claim, Novatec^[53]).

The key to sizing is the pump's hourly time budget, and this budget must be built on peak demand, not on average demand. An industry source recommends that the receiver be large enough to meet the machine's consumption, and that small receivers be replaced with larger ones to reduce the number of fill cycles per hour (Plastics Technology, Follow These Steps...^[14]). The arithmetic is as follows: required cycles per hour $n = Q / (\rho \cdot V \cdot f)$, where Q is machine consumption (kg/h), ρ bulk density (kg/L), V receiver volume (L) and f the fill ratio. A machine consuming 60 kg of PP per hour (assuming $\rho \approx 0.55$; $f \approx 0.8$) with a 6 L receiver requires about 23 cycles per hour. If each cycle, with conveying and discharge, occupies

the pump for 25 s (assumption), this machine uses about 570 s of pump time per hour; ten machines connected to the same pump require about 5,700 s, which does not fit into a 3,600 s hour. When the receiver is enlarged to 12 L, cycles fall to about 11 per hour, the total for ten machines becomes about 2,850 s, and the pump is busy about 79% of the time (Teknik Part calculation; all inputs are assumptions). What the calculation teaches is that enlarging the receiver can be a cheaper capacity lever than enlarging the pump, but that a high occupancy leaves no margin at peak moments (several machines emptying at once). A supplier states that one of the most frequent design errors is failing to design for simultaneous peak demand rather than the average; it recommends sizing on the actual bulk density rather than the catalog default, and a variable-frequency drive rather than a fixed-speed motor in multi-material plants (WIJAY Systems^[54]; the velocity values in the same article have not been used in this report). No published rule could be found in manufacturer sources for a simultaneity factor or for the question "how many minutes of consumption should the machine hopper hold"; it is stated that a central line can feed up to 10 loaders simultaneously from the same vacuum source, whereas in a single-line system only one loader draws at a time (manufacturer's claim, motan^[47]). Central systems typically have 8, 16, 32 or 64 receivers connected (US Patent 10179708^[25]); these tiers are control capacity, not pump capacity (Teknik Part interpretation).

The hidden cost of a shared material line design is line purging. A line purge (purge / material cut-off) valve cuts off the material in the last seconds of the cycle and lets only air into the line, so that dried or blended material does not sit in the line. However, according to an industry article, when line purging is used there can be **a loss of up to about 50% in system capacity**, depending on the distance from the source to the machine, and the pump must be selected large enough to cover the "lost time" during which the line carries only one charge (Plastics Technology, Follow These Steps...^[14]). This is a quality-capacity trade-off: it is mandatory for hygroscopic and dried materials such as PA, PET and PC, but if it is left on unnecessarily for PE and PP, which require no drying, it can halve capacity (Teknik Part interpretation).

Preventing material mix-ups is the most underrated gain of a central system. According to one manufacturer, manually changing uncoded couplings in manual conveying systems is a hidden source of error, and if the wrong material reaches the machine the consequences are expensive (manufacturer's claim, motan: Coded material assignment with RFID^[55]); another manufacturer emphasizes that a wrong-material error usually goes unnoticed at first and produces a large number of defective parts (manufacturer's claim, Wittmann CODEMAX bulletin, 2021^[56]). There is a cost-safety ladder here: color coding is only a visual reminder and does not prevent the error; an RFID-coded coupling checks the connection against the control, stops conveying in the event of a wrong or open connection and can often be retrofitted to existing distributors; automatic coupling stations remove the human step altogether (Teknik Part interpretation, from manufacturers' descriptions). No independent statistics could be found on the frequency or cost of wrong-material incidents.

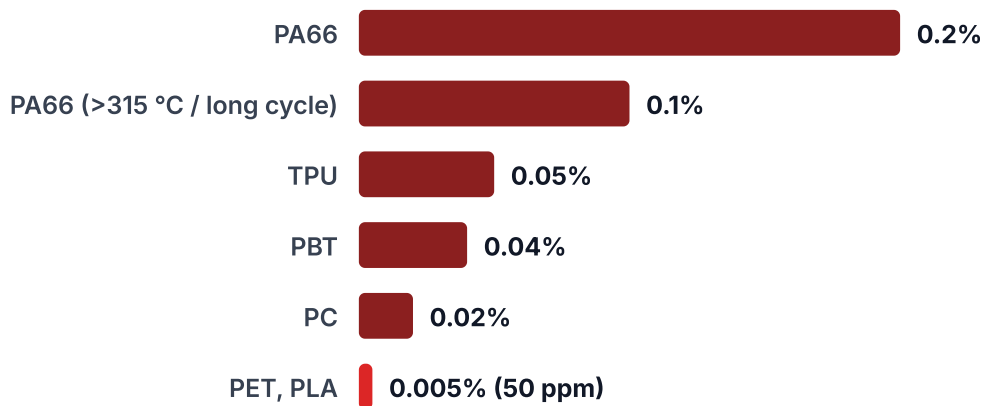
7 · RAW MATERIAL CHAIN AND QUALITY

The raw material chain determines part quality: moisture, particle size, ratio and metal

Part quality becomes visible in the mold, but a substantial share of defects arise before the raw material reaches the feed throat: moisture, fines, ratio deviation, dirty regrind and metal. Wherever possible, this section measures each link of the chain against the limit set not by the equipment manufacturer but by the resin producer itself.

Resin producers stipulate moisture limits and closed conveying in their datasheets

The strongest quality argument in favor of central conveying comes from the resin producer. A PA66 producer writes that moisture must be **below 0.2% by weight** for molding, that strength and toughness fall above this value, and that at melt temperatures above 315 °C or with long cycles moisture as low as **0.1%** may be required; excess moisture forms steam that causes splay, and lowers melt viscosity, increasing the risk of flash (DuPont Zytel & Minlon Molding Guide, pp. 3 and 7^[57]). A PBT producer requires moisture **below 0.04%** for processing and states explicitly in its datasheet that predrying is the rule and that the machine must be fed by a **closed conveying system** (resin producer, BASF Ultradur B4521 PRO processing datasheet^[58]). A TPU producer recommends drying to **0.05% or below**; excess moisture leaves bubbles and marks on the surface (Covestro, Processing of TPU by Injection Molding, p. 7^[59]). For PC, a maximum residual moisture of 0.02% is given for injection molding (resin producer, Covestro Makrolon product range^[60]). According to an independent expert, hygroscopic materials with cosmetic requirements can be processed at 0.05–0.10%, while performance-critical polymers must not be processed above 0.02%; PET and PLA may require a level of **50 ppm**, and nylon can absorb 8–9% water at saturation (Plastics Technology, M. Sepe: Why (and What) You Need to Dry^[61]); an industry article on PET drying likewise gives the target moisture as 0.005% (50 ppm) (Plastics Technology, How to Dry PET for Container Applications^[62]). The consequence of moisture is not only a surface defect: the same PA66 producer asks that parts embrittled by high-moisture pellets or long residence times be scrapped rather than ground and reused (DuPont, p. 32^[57]). These datasheet statements turn closed and dry conveying from a preference into part of the material specification (Teknik Part inference).

Figure 7 Maximum residual moisture for processing given by resin producers (% by weight)

Source: DuPont (PA66)^[57], Covestro (TPU^[59], PC^[60]), BASF (PBT)^[58], for PET and PLA, Plastics Technology^[61,62].

Dried pellets return to the threshold on a scale of minutes

The result of drying is preserved or lost in the time between the moment the pellets leave the hopper and the moment they reach the feed throat. The moisture uptake chart in the TPU producer's guide plots the rise of dried ester- and ether-based pellets at 23 °C and 50% relative humidity toward the 0.05% processing threshold on an axis of **0–16 minutes**; the same guide asks that hot dried pellets not be left to cool in open air and that the machine hopper be kept closed (Covestro TPU guide, pp. 6–7^[59]). Because the minute at which the chart crosses the threshold cannot be read from the text, no minute value is given in this report; what is certain is that the producer plots this uptake on a scale of minutes, not hours. The PA66 producer likewise writes that at moderate humidity levels the rate of moisture uptake can be fast enough, in material dried in a separate dryer and placed in an open hopper, to prevent uniform molding over time; for this reason manually transferred tray ovens are not recommended and hopper dryers are preferred (DuPont, pp. 7–8^[57]). The same source states that regrind absorbs more moisture, and faster, than virgin pellets, and asks that it be kept in closed containers and that a container coming from cold storage be brought to ambient temperature before opening to prevent condensation (DuPont, pp. 6 and 32^[57]). The practical rules in industry articles point the same way: dried polymer should generally be processed **within 30 minutes** (Plastics Technology, J. Bozzelli: You Must Dry Hygroscopic Resins^[63]), and dried material should be conveyed with dry air rather than shop air (Plastics Technology, Central Drying Made Simple^[64]). The minute scale of the TPU chart suggests that for the most sensitive materials even the 30-minute rule may be optimistic (Teknik Part inference). The measured curves are for pellets standing in an open hopper and in ambient air; no independent study measuring how much moisture pellets absorb inside a pneumatic conveying line could be found.

Three arrangements for conveying with dry air have been described: a closed loop in which the conveying air is drawn from the return line of the drying hoppers and the pump exhaust is returned to the return line just before the dryer; a classic closed loop that does not use return air; and a single-pass open loop with a separate dehumidifier; the last requires care in humid plants, because it can only go

about 30 °F (≈ 17 K) below the ambient dew point (Plastics Technology, Central Drying Made Simple^[64]). The same article reports that moisture regain during conveying is solved by purging the line after each cycle and by a dry-air blanket from the moment the material leaves the hopper until it reaches the machine, and that line purging with dry air after dry-material cycles is recommended even for ABS, which is less sensitive than PET and PA 6 (Central Drying Made Simple^[64]). The crux of the problem is often the machine hopper: after conveying, material can sit there for a long time; the solution is to shorten the residence time (a small machine loader instead of a large machine hopper) or to keep the hopper under a dry-air blanket (Teknik Part interpretation; for the dry-air blanket, Central Drying Made Simple^[64]). This conflicts directly with receiver sizing: a receiver enlarged for the pump's time budget lengthens the residence time of dried material. On lines that feed dried material, receiver and hopper volumes should be checked against the 30-minute rule above before the capacity calculation (Teknik Part interpretation). Here, too, lies an operating gain of the central system: a material change at the machine (emptying, cleaning, refilling, drying) can take up to 5 hours, whereas in new central systems it comes down to a few minutes (manufacturer's claim, Central Drying Made Simple^[64]).

Drying energy is affected by conveying design. In one manufacturer's test table normalized to 100 lb/h, the following were measured for PC: vacuum dryer 3.71, desiccant wheel 6.18, membrane 4.41 and twin-bed 7.11 kWh/100 lb (≈ 0.157 kWh/kg for twin-bed) (manufacturer's test data, Plastics Technology, How to Compare Dryers^[65]; vacuum and membrane dryers also use compressed air, and this consumption is not included in the kWh values); the same article reports that heat recovery from the drying hopper outlet can reduce energy by up to 25% in high-temperature drying. In a central system, closing the air valve when the hopper outlet dew point equals the inlet dew point prevents overdrying of nylon (manufacturer's claim, Central Drying Made Simple^[64]). Manufacturer claims about the energy advantage of wheel and twin-bed dryers contradict one another (Canadian Plastics: The Drying Game^[66], archived copy); there is no independent kWh/kg comparison for PA, PET and PBT.

The other end of drying produces defects too. The PA66 producer writes that long drying at high temperature can lead to the loss of some additives and to discoloration of the pellets, and asks that the temperature be lowered if drying time is to be extended and that the hopper and the air conveying lines be insulated for drying above 105 °C (DuPont, p. 8^[57]). It is also reported that in nylon drying beyond about 12 hours, viscosity rises continuously and the process requires constant adjustment (UL Prospector: Overdrying of Resins^[67], archived copy; an equipment manufacturer in the same vein: Novatec, Overdrying Nylon^[68]). In a central system the typical source of overdrying is a drying hopper chosen too large for the consumption; hopper volume should be sized on the product of consumption and drying time, and regeneration should be controlled by dew point and temperature (Teknik Part inference).

Ratio, fines and regrind quality spoil color and melting

On the dosing side, the rule is clear: the closer to the point of processing the blend is made, the more homogeneous it remains. In an industry publication, a photograph shows that a blend made about 200 ft (≈ 60 m) from the machine and then conveyed separated visibly (virgin material and color), whereas a blender beside the machine gave a homogeneous blend; the ideal is for blending to be done directly at the feed throat or on the mezzanine immediately above it (Plastics Technology, Five Quick Steps Toward Better Blending^[69]). The bulk density and particle size of regrind vary widely; small, light particles separate from large, heavy pellets and stratify in the feed throat (Five Quick Steps^[69]). Proportioning valves on the loader merely layer the material into the loader in approximate ratios; no real mixing takes place and the result is highly irregular (Plastics Technology KC: Blender Alternatives^[70]). In current batch-type gravimetric blenders the dosing tolerance per component is by default 0.05% of batch weight and can be reduced to 0.02%; continuous (loss-in-weight) blenders hold the target throughput within $\pm 0.5\%$, but at very low throughputs such as 0.25 kg/h the error can rise to $\pm 2\%$ (author from a blender manufacturer, Plastics Technology, Understanding Gravimetric Blender Accuracy & Payback^[71]). One application recommendation is a dual recipe tied to the regrind bin level (40% regrind/60% virgin when the bin is full, 20%/80% when it is low), so that regrind consumption matches its generation (Five Quick Steps^[69]). The architectural conclusion is that the central system should carry single components to the machine-mounted gravimetric blender and that the blend should not be conveyed through a long line, particularly for masterbatch at 1–4% and for regrind (Teknik Part interpretation).

The quality impact of a dosing error grows as the masterbatch ratio falls. In a masterbatch producer's example, a dosing error of ± 0.1 g means, at a 1% ratio, a relative deviation of $\pm 10\%$ and, at a 3% ratio, $\pm 3.3\%$ (masterbatch producer, Colourhouse Masterbatch, Addition rates explained^[72], archived copy); this arithmetic shows that, for an operation that wants to reduce its masterbatch ratio, dosing accuracy is a precondition (Teknik Part inference). In color acceptance the industry's pass/fail criterion is $\Delta E = 1$; if the color changes even though the masterbatch is dosed at the agreed ratio, the likely root cause is poor dispersion (trade publication, Interplas Insights, Understanding Colour Variation^[73]). The two sources of color deviation must therefore be separated: the ratio varying from shot to shot (dosing and segregation, i.e. the raw material chain) and the melt failing to mix while the ratio is correct (screw, mixer and carrier compatibility); central conveying and machine-mounted dosing solve only the first (Teknik Part inference). The TPU producer gives masterbatch dosing as typically 1–4%, writes that a static mixer in the adapter markedly improves color distribution and reduces the amount of colorant, and states that color pellets with polyolefin or PVC carriers are not suitable for TPU (Covestro TPU guide, p. 8^[59]). No independent study could be found linking dosing deviation to measured ΔE , or blend segregation to line length; the evidence we have on segregation is the qualitative photograph mentioned above.

Figure 8 Relative deviation of a ± 0.1 g dosing error by masterbatch ratio

Source: masterbatch producer's example ^[72]. As the ratio falls, the same error in grams produces a larger relative deviation in color.

The root of regrind's conveying problems usually lies in the granulator. Good practice is to grind regrind to a uniform particle size compatible with the virgin pellets and to deliver the blend at the same bulk density every cycle (Plastics Technology, Smart Handling of Regrind ^[74]). Dust and fine particles cause bridging and rat-holing in granulator discharge bins, accumulate in the feed hopper and lead to clogged filters that reduce conveying capacity; in the process, fine particles melt faster than virgin pellets and degrade, causing black specks and thus scrap and inspection costs; their sources are dull and misadjusted knives, clogged screens, excessive rotor speed and small screen holes (Plastics Technology, Eliminate Dust, Fines and Longs For Better Regrind Quality ^[75]).

The damage mechanism of fines lies in the feed zone of the screw. According to an independent expert, fines melt much faster and earlier than normal pellets, which reduces the friction needed to melt the normal pellets; the result is unmelted pellets and black and white specks (Plastics Technology, J. Bozzelli: Why Pellet Size and Shape Are Important ^[76]). The PA66 producer asks that regrind particles be the size of fresh pellets (with an approximately 5 mm screen, particles of about 3 mm) and that fines be separated with an approximately 2.5 mm screen, and writes that fines quickly absorb moisture and clog vacuum loader filters (DuPont, p. 32 ^[57]). Fines thus harm the chain in three ways: they disturb melting, carry moisture and reduce loader capacity by clogging the filter (Teknik Part inference). No binding published limit could be found for an acceptable fines content; a patent for minimal-shear and rotational molding micropellets prefers pellets containing less than 1%, preferably less than 0.1%, dust (patent claim, not an industry limit – US Patent 8,969,435 ^[77]). Limiting the conveying velocity limits the generation of fines, and a deduster on the machine separates them at the final stage.

Resin producers limit regrind more by quality than by percentage. The PA66 producer recommends using regrind only at the rate at which it is generated, at **at most 50%, preferably 25%** with virgin material, and writes that final properties depend more on the quality of the regrind than on its percentage; in parts carrying mechanical loads regrind should be used only rarely, the acceptable amount should be determined by testing for each part, and parts that are discolored or show splay should not go into regrind (DuPont, pp. 31–32 ^[57]). The TPU producer asks that the share of recycled material not exceed **30%** and that only clean, sorted scrap be used (Covestro TPU guide, p. 15 ^[59]).

Regrind also works cumulatively: in an independent expert's example, in a process with 20% scrap a 1,000 lb batch yields 200 lb of scrap on the first pass; when this scrap is processed as 100% regrind on the second pass, 40 lb of scrap remain, and 8 lb on the third pass, and the author recommends selling the last 8 lb; the range of practice in the industry is 0% to 100%, and in medical the typical answer is "none" (Plastics Technology, J. Bozzelli: Another Way to Deal with Regrind^[78]). These rules show that the regrind ratio is not a setting but a system output: particle size is set at the granulator, fines at the separator, moisture by the closed container and ratio by gravimetric dosing (Teknik Part inference).

Metal separation is completed at the last link, the feed throat

Metal separation is a layered defense, and its last link is the machine feed throat. The layout recommended by a magnetic separator manufacturer consists of an in-line magnet and metal detector at the first entry into the warehouse, a drawer or in-line magnet at the silo outlet, a detector on the molding line, a grate magnet, drawer magnet or machine-mounted all-metal separator in the hopper, and separate separators in the regrind/recycling loop (manufacturer's claim, Bunting: Metal Separator Locations in a Plastics Plant^[79]). Magnets hold only ferromagnetic metal; for non-magnetic metals such as aluminum and stainless steel an all-metal separator is required (manufacturer's claim, motan: Metal separator^[80]). Patent literature states that loose metal causes serious wear and breakage in the screw and barrel through its grinding action (US Patent 5,427,249^[81]). Because contamination can enter the system after the central separators too (regrind, manual loading, line wear), last-point protection at the feed throat is indispensable (Teknik Part interpretation). No reliable published figure could be found for the cost of screw and barrel damage. The effect of metal on part quality is indirect: clogging of or damage to a hot runner nozzle or the check valve produces unbalanced filling and short shots, and screw and barrel wear produces shot inconsistency (Teknik Part inference; no source quantifying this chain could be found).

With powdered materials (powder masterbatch, powder additives) the picture changes: vacuum conveying is the preferred closed process for combustible dusts, particles below 10 µm can remain airborne for days, and conductive filters and reverse-jet cleaning are required (supplier author, Plastics Technology, Seven Key Factors When Vacuum Conveying Powders^[82]). The source refers to US standards; although it is known that the relevant framework in Turkey and the EU is the ATEX legislation, no ATEX-specific source was reviewed in this study, and this should be assessed separately in powder conveying projects.

The quality argument in this section has a limit: **no independently measured percentage reduction in scrap attributed to central conveying or central drying could be found.** In the published case the causes of the earlier scrap are listed, but the subsequent scrap rate is not given (Plastics Technology, 2006^[52]). The quality case should therefore be built not on scrap promises but on the datasheet requirements of the resin producers. Table 2 matches these requirements with the root cause in the chain and the preventive practice.

Table 2 Defects arising from the raw material chain

Defect	Root cause in the chain	Preventive equipment / practice	Threshold and source
Splay (moisture streaks), bubbles, brittleness	Insufficient drying; dried pellets absorbing moisture in an open hopper or while being conveyed with ambient air	Hopper-type dryer, closed conveying with dry air, line purging, small receiver and hopper volume, closed hopper	PA66 $\leq 0.2\%$, 0.1% if needed (DuPont ^[57]) · PBT $< 0.04\%$ (BASF ^[58]) · TPU $\leq 0.05\%$ (Covestro ^[59]) · PC $\leq 0.02\%$ (Covestro ^[60]) · PET/PLA ~50 ppm (Sepe ^[61])
Viscosity shift, flash or fluctuating short shots	Moisture fluctuation (in PA, moisture lowers viscosity) or overdrying	Drying controlled by dew point and temperature; hopper sized to consumption	DuPont, p. 7 ^[57] ; viscosity increase with drying beyond ~12 hours (UL Prospector ^[67] , archived copy)
Discoloration, loss of additives	Long drying at high temperature	Lowering the temperature for long drying; insulating hopper and line above 105 °C	DuPont, p. 8 ^[57] (qualitative)
Unmelted pellets, black or white specks	Fines, angel hair, regrind dust	Conveying velocity limit, machine-mounted deduster, screening fines out of regrind	~2.5 mm screen (DuPont, p. 32 ^[57]); $< 1\%$ dust, preferably $< 0.1\%$ (patent, not binding)
Color deviation, color streaks	Dosing deviation, segregation of the blend in a long line; or dispersion and an incompatible carrier	Machine-mounted gravimetric dosing, static mixer, compatible carrier	± 0.1 g error at a 1% ratio = $\pm 10\%$ (Colourhouse ^[72] , archived copy) · $\Delta E = 1$ pass/fail (Interplas ^[73])
Loss of mechanical properties	High or irregular regrind ratio; degraded, wet or dirty regrind	Gravimetric proportioning of regrind at the rate it is generated, closed container, particles the size of fresh pellets	PA $\leq 50\%$, preferably 25% (DuPont, p. 31 ^[57]) · TPU $\leq 30\%$ (Covestro, p. 15 ^[59])
Mixed material, foreign specks	Wrong container or coupling, dirty regrind	RFID-coded or automatic coupling, closed line, line purging	No numerical threshold (motan, Wittmann; manufacturer)
Damage to screw, nozzle or check valve; shot inconsistency	Metal particles	Layered magnetic and all-metal separation, last-point protection at the feed throat	No numerical threshold (Bunting ^[79] ; manufacturer)

8 · PAYBACK

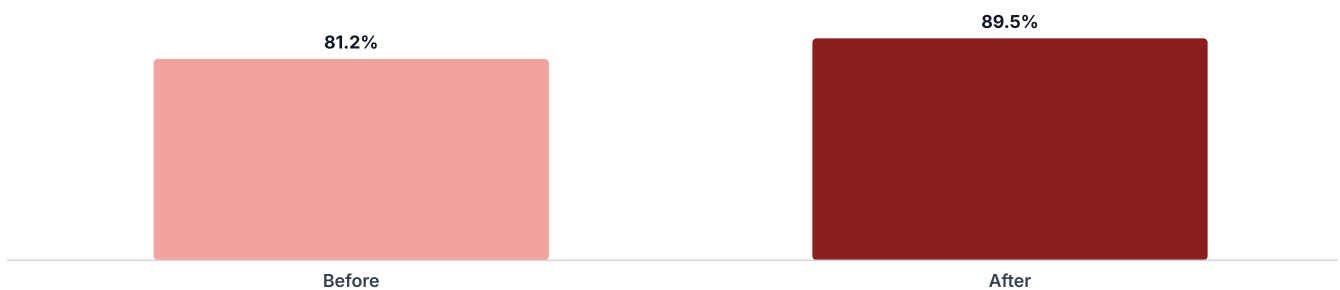
Payback comes from labor and scrap; energy is an additional gain

The strongest published case with numerical data belongs to a US molder operating 21 injection presses (90–720 tons) with up to 20 different materials and more than 30 colors. An investment of **\$250,000** was made in material handling equipment and a mezzanine refurbishment, with an expected payback of **14–16 months**; it is claimed that **one full-time material handler per shift was no longer needed**, that 27 storage locations and machine-side stock were eliminated, and that savings of 3–5 ¢/lb on raw material were achieved through bulk purchasing and about 20 ¢/lb in total through better handling and drying.

The causes of the earlier scrap were listed as contaminated material, use of the wrong material, faulty drying and color mixing; workplace safety improved as forklift traffic decreased; a single central dryer feeds eight drying hoppers (Plastics Technology, Material Handling and Drying Are a Molder's 'Central' Issue, 2006^[52]). The figures appear in a magazine report but are customer and supplier claims; \$250,000 and 14–16 months correspond to net savings of about \$15,600–17,900 per month (Teknik Part calculation). The lesson of the case is that the main items of the payback are not energy but **labor and material loss**.

The second case is a project at a medical plant with 70 injection molding machines, in which 192 RFID-tagged connections ensure that the right material goes to the right machine and about 4 miles of piping were installed; the plant's OEE rose from 81.2% to 89.5% (Plastics Technology, Medical Molder Boasts Showpiece Material-Handling System, 2021^[83]). This OEE increase is a plant-wide indicator and cannot be attributed to the material system alone. In a frequently cited third case, a molder is reported to have replaced 30 oil-lubricated rotary vane vacuum pumps mounted on each machine with two central pumps and buffer tanks, claiming a 75% reduction in energy (Plastics Technology, Switch to Centralized Vacuum Supply..., 2018^[84]); however, the text states clearly that this vacuum is process (mold) vacuum used to evacuate the mold cavity. This case therefore **cannot be used as a raw material conveying case**; it has value only as a limited precedent for the argument of "a central vacuum source instead of pumps at each machine".

Figure 9 OEE at a medical plant with 70 machines: before and after the material system project



Source: Plastics Technology^[83]. It is a plant-wide indicator; the increase cannot be attributed to the material system alone.

No central raw material conveying case with independent measurement and verification (M&V) and before/after energy data has been published; nor could any named project with figures be found in the Turkish trade press, where what was found were vendor pages containing no numerical cases (Hastek^[85], Polmak^[86]). For a Turkish molder, the investment case must therefore be built on its own data: (number of material handlers eliminated × annual fully loaded labor cost) + (reduced scrap × raw material price) + (avoided cost of wrong-material and contamination incidents) + (energy difference), compared with the investment (Teknik Part method, derived from the items of the case). A general claim of "pays back in so many months" is unsourced and has not been used in this report.

APPLICATION

Application tools: checklist, error table and measurement set

The checklist below has been compiled by Teknik Part from the sourced findings in the previous sections; the basis for each row is given in the relevant section. The section numbers in the tables follow the order of headings in the report (1 velocity, 2 line geometry, 3 dust-wear-leakage, 4 pump and energy, 5 machine-side loader and central system, 6 architecture and sizing, 7 raw material chain and quality, 8 payback).

Table 3 Design and commissioning checklist (Teknik Part compilation)

Stage	What to check	Basis
Data collection	Have each machine's actual consumption (kg/h), the simultaneous peak demand and the actual bulk density of the material (not the catalog value) been measured?	Section 6; WIJAY (sizing principle)
Data collection	Which materials are dried, which are regrind or filled/glass-fiber-reinforced, which are powders?	Sections 3, 7
Choice of arrangement	Has a machine-side, small central or full central arrangement been chosen according to the number of machines, distance, number of materials and drying need; has the transition been planned in stages?	Section 5
Machine-side loader	Is the source container within the 4–5 m datasheet condition; are brush operating hours monitored; is hygroscopic material standing in an open container?	Sections 5, 7
Central system	Is there a standby pump that cuts in automatically; can the pump be located outside the production hall?	Section 5
Line routing	Has the equivalent length been calculated (horizontal + 2 × vertical + number of bends × bend equivalent + hose)? Has the equivalent-length rule used to prepare the pump curve in use been obtained from the manufacturer?	Section 2; Mills 2004 ^[5]
Line routing	Has the number of bends been minimized, is there straight pipe between consecutive bends, and has a ~6 m straight acceleration zone been left after the feed point?	Section 2; Chemical Engineering
Line routing	Is flexible hose used only at couplings and machine connections, and have coiled loops been removed?	Section 2
Velocity	Has the pickup velocity been calculated within the ~15–20 m/s band for pellets and with a 20% safety margin, and was the actual pipe bore used?	Section 1; Mills 2004 ^[5]
Velocity	Does the end-of-line velocity exceed ~30 m/s? If so, have a stepped line, velocity control or controlled air bleed been considered?	Section 1
Pump	Is the pump type suited to the equivalent distance and the required vacuum (side-channel / multistage / lobe / claw)?	Section 4
Pump	For curves given for 60 Hz, has the capacity drop at 50 Hz (~17%) been taken into account?	Section 4; Plastics Technology
Pump	Does the pump's hourly time budget fit into 3,600 s at peak demand, with a margin?	Section 6 (Teknik Part calculation)

Stage	What to check	Basis
Pump	Is the idle time compatible with the start limit (e.g. ≤ 10 per hour)? Is a parallel pump or buffer volume needed?	Section 4
Filter	Is the central filter suited to dusty material and to the pump power; are automatic cleaning and the dust bin accessible?	Section 4
Drying	Is dried material conveyed with dry air, and is the line purged after every cycle? Does the receiver/hopper volume exceed 30 minutes of consumption?	Section 7
Drying	Has the capacity loss of line purging (up to $\sim 50\%$) been included in pump sizing; is purging left on unnecessarily on lines that need no drying?	Section 6
Drying	Has the residual moisture limit for each material been taken from the resin producer's datasheet; is the machine hopper closed; is a drying hopper chosen too large for consumption leading to overdrying?	Section 7; DuPont, BASF, Covestro
Dosing	Is the blend made on the machine; is a pre-blended mix being conveyed through a long line?	Section 7
Dosing	For low-ratio (e.g. 1%) masterbatch, has dosing accuracy been converted into relative deviation; is color acceptance (ΔE) carried out with dosing and dispersion monitored separately?	Section 7
Regrind	Is the regrind ratio within the resin producer's limit (e.g. PA $\leq 50\%$, preferably 25%; TPU $\leq 30\%$); is regrind consumed at the rate it is generated and from a closed container; are fines separated with a screen?	Section 7; DuPont, Covestro
Regrind	Are the particle size and dust content of regrind controlled at the granulator; has the diameter of the regrind line been assessed separately from pellets; is the receiver discharge diameter sufficient?	Sections 1, 7
Metal	Are there layered separators at the silo inlet, silo outlet, regrind loop and feed throat; is an all-metal separator needed for the risk of non-magnetic metal?	Section 7
Wrong material	Has the coding level at the coupling station (color / RFID / automatic) been chosen according to the cost of an error?	Section 6
Wear	On glass-fiber/filled lines, was velocity reduced first, and only then a wear-resistant bend chosen?	Section 3
Installation	Are pipe ends aligned and chamfered, are couplings vacuum-tight, is there grounding on glass lines?	Section 3
Expansion	Has margin been left in control, distributor and pump capacity for future machines?	Section 6 (inference from manufacturers' design for later expansion)

The table below brings together the design and operating errors documented in the sources, their consequences and the way to correct them.

Table 4 Common errors → consequence → solution

Error	Consequence	Solution	Source
Upsizing the pump "so that it is enough at the end of the line", raising the pickup velocity well above 20 m/s	Wear increases with ~the 2.5th power of velocity; bend life is ~halved with every +4.5 m/s (manufacturer's claim); angel hair and dust	Set velocity for the pickup point; velocity control, flow limiter, stepped line	Chemical Engineering; Plastics Technology; Mills 2004 ^[5]
Keeping the pickup velocity at the limit, calculating with the nominal diameter instead of the actual bore	Saltation in horizontal runs, plugging in vertical runs and after bends	20% velocity margin; actual bore	Mills 2004 ^[5] ; Powder & Bulk Solids
Ignoring the bend equivalent, using consecutive bends	Equivalent length rises far above physical length; material drops out of the flow	Simplify the route, put straight pipe between bends	Mills 2004 ^[5] ; Plastics Technology
Excess flexible hose, coiled loops	Marked additional pressure loss at high velocity, drop in throughput	Shorten the hose, use rigid pipe	Mills 2004 ^[5] ; Novatec VLP (manufacturer)
Using a 60 Hz pump curve on a 50 Hz grid without correction	~17% lower capacity, operation below the target velocity	Apply a frequency correction, ask the manufacturer for a 50 Hz curve	Plastics Technology
Sizing for average consumption	Hoppers run empty at peak moments, "no material" alarm	Size by peak demand and pump time budget; optimize receiver volume	WIJAY; Plastics Technology; Teknik Part calculation
Conveying dried material with shop air, leaving it in a large machine hopper	Moisture regain; the drying investment is wasted	Conveying with dry air, line purging, receiver/hopper holding at most 30 minutes of consumption	Plastics Technology (Bozzelli; Central Drying Made Simple)
Leaving line purging on in lines that need no drying	Capacity loss of up to ~50%	Use line purging only for hygroscopic/dried and blended material	Plastics Technology
Blending centrally and conveying the blend through a long line	Segregation of color and regrind, stratification	Machine - mounted gravimetric blending	Plastics Technology
Assuming that a proportioning valve "blends" regrind	Crude, irregular ratio	Convey regrind separately, dose it gravimetrically	Plastics Technology KC
Misaligned pipe coupling	Fines torn off regrind and pellets	Align, chamfer the downstream end	INEOS
Uncoded manual coupling	Wrong material, defective parts noticed late	RFID - coded or automatic coupling station	motan, Wittmann (manufacturer)
Leaking check valve on an idle loader, worn seal	Capacity loss at the other loaders; invisible vacuum leak	Monthly seal check, yearly vacuum valve check; smoke test	Ferlin MOVAC manual; Mills 2004 ^[5] ; Plastics Technology

Error	Consequence	Solution	Source
Neglecting filter maintenance, switching off filter cleaning	Drop in capacity; in the worst case collapse of the filter housing	Weekly emptying of the dust bin, pulse setting, safety valve check	Ferlin MOVAC manuals; Plastics Technology
Stopping and starting the pump too often	Shorter motor and pump life	Set the idle time in line with the start limit	Ferlin MOVAC manual
Leaving dried material in an open hopper, transferring it by hand from a tray oven	Moisture uptake on a scale of minutes; splay, brittleness	Hopper dryer, closed hopper, conveying with dry air	DuPont; Covestro
Choosing a drying hopper too large for consumption, long and hot drying	Loss of additives, discoloration, viscosity shift	Choose hopper volume by consumption × drying time; lower the temperature for long drying	DuPont; Teknik Part inference
Using regrind without screening and dedusting	Unmelted pellets, specks, filter clogging	Particles the size of fresh pellets, separation of fines with a ~2.5 mm screen, deduster	DuPont; Bozzelli
Treating the regrind ratio as a fixed setting, grinding degraded parts	Loss of mechanical properties	Gravimetric proportioning at the rate of generation, within the producer's limit; separate out degraded parts	DuPont; Covestro
Not monitoring brush hours on machine-side loaders	Unexpected stoppage, machine running empty	Brush alarm and planned replacement; brushless type	Novatec, Shini (manufacturer)
A single central pump without a standby	A single failure stops all connected machines	Standby pump that cuts in automatically	motan (manufacturer)
Conveying pellets with compressed air (venturi)	~10 times the cost of electricity at the point of use	Central vacuum with an electric motor	GPG 292; Van Ormer
No metal protection at the feed throat	Screw and barrel damage	Layered separators + last-point protection	Bunting (manufacturer); US patent literature

On the measurement side, no published KPI benchmark for the industry could be found. The set below has been derived by Teknik Part from measurable quantities that appear in the sources; target values have deliberately not been given until the plant has measured its own baseline.

Table 5 Proposed KPI set (derived by Teknik Part; no industry benchmark values exist)

Area	Indicator	How it is measured	What it shows
Energy	kWh per ton conveyed	Pump energy meter ÷ raw material processed in the same period	Efficiency of pump type, velocity and duty cycle

Area	Indicator	How it is measured	What it shows
Energy	Pump on-load ratio	Hours on load ÷ total operating hours	Capacity running idle, need for staging
Energy	Compressed air for filter cleaning and valves	Nm ³ /shift (separate meter or calculation)	Hidden compressed air cost
Capacity	Receiver fill time	Seconds for each receiver, trend against the baseline	Leakage, filter clogging, velocity loss (early warning)
Capacity	Cycles per hour per receiver and pump time budget occupancy	Control logs; $\Sigma(\text{cycles} \times \text{duration}) \div 3,600 \text{ s}$	Margin remaining at peak demand
Capacity	Capacity share of line purging	Purge time ÷ total cycle time	Unnecessary purging
Reliability	"No material" alarms / shift	Control alarm log	Adequacy of sizing for peak demand
Reliability	Line plugs and filter alarms / month	Alarm and maintenance log	Velocity margin, filter maintenance
Reliability	Filter differential pressure	mbar, periodic reading	Filter condition, cleaning setting
Quality	Wrong - material incidents / year	Quality records	Adequacy of the coupling coding level
Quality	Residual moisture at the feed throat (as a ratio of the resin producer's limit)	Moisture analyzer on a sample taken from the throat	Combined result of drying and conveying; whether the limit is exceeded
Quality	Dryer outlet/return dew point and hopper residence time	Dew point sensor; hopper volume ÷ consumption	Drying adequacy and overdrying risk
Quality	Fines content in regrind	Sieve analysis, % by weight	Condition of granulator knives and screen; risk of specks and filter clogging
Quality	Actual ratio of regrind and masterbatch	Gravimetric dosing log; % deviation from target	Ratio stability
Quality	Color difference (ΔE)	Spectrophotometer, per batch	Combined result of dosing and dispersion
Quality	Amount of dust and angel hair	g/ton collected from the deduster or filter bin	Degradation caused by velocity and bends
Quality	Pieces retained in the metal separator / month	Separator inspection log	Source and trend of contamination
Organization	Material changeover time	Minutes, per changeover	Flexibility gain of the central system
Organization	Man - hours of manual machine-side feeding and forklift movements	Shift log	Tracking of the labor-based payback
Maintenance	Bend and pipe replacement interval	Replacements per shot or per ton	Effect of wear and of the velocity setting
Maintenance	Brush operating hours and annual number of replacements on machine-side loaders	Control counter, maintenance log	Hidden maintenance load of the self-contained loader

Area	Indicator	How it is measured	What it shows
Reliability	Number of standby pump activations	Control alarm log	Condition of the main pump, single-point-of-failure risk

METHOD

Data gaps and methodological note

The limits of this report must be stated clearly. First, **there is no independent, measured kWh/ton benchmark for central vacuum conveying**; government guides list materials handling as an energy item but give no percentage or kWh/t, and the figures in circulation come from unsourced supplier articles and have not been used in this report.

Second, **no independent kg/h–distance tables could be found** for in-plant vacuum lines of 40–60 mm; Mills' measurements are mostly on test lines of 53 mm bore and above with pressurized feeding (blow tank, rotary valve), and manufacturers' capacity tables are valid only for their own equipment and their own equivalent-length rules.

Third, **the report's local archive contains no capacity–distance curves, pump kW–m³/h–mbar curves or frequency converter information for Ferlin MOVAC pumps and loaders**; these data are not in the Teknik Part archive and should be requested from the manufacturer as technical datasheets.

Fourth, **there is no independent measurement comparing the machine-side self-contained loader and the central system in terms of energy, labor, noise, scrap or quality**; the figures of 80% energy and 1–2% raw material savings circulating in favor of the central system are manufacturer claims, and the latter is also given by the same manufacturer for a simple machine-mounted loader. No dB(A) value measured at the machine, independent failure rate for brushed motors, standby pump switchover time or survey data on how common the machine-side arrangement is in Turkey could be found either.

Fifth, in the quality chain, resin producers give moisture uptake curves for open hoppers and ambient air, but **there is no study measuring how much moisture pellets absorb inside a pneumatic conveying line**; likewise, **no quantitative data linking blend segregation to line length**, no binding fines limit from a resin producer, no study linking dosing deviation to measured ΔE and no independent measurement of a scrap reduction attributed to central conveying or drying could be found.

Sixth, no sourced data could be found on a fixed pressure loss ratio for flexible hose relative to rigid pipe, on agreement among manufacturers about the horizontal equivalent of a vertical meter, on the energy effect of filter pressure drop, on the quantitative cost of uncontrolled leakage, on the pickup velocity of regrind, on the comparative wear rates of bend materials or on the frequency of wrong-material incidents.

Seventh, no named central conveying project with figures has been published in Turkey.

The topics excluded from the scope, mold temperature control, cooling and chiller systems, have not been assessed in this report; for this reason no conclusion whatsoever about the cooling side of plant energy should be drawn from this report.

About the sources: a substantial proportion of the trade magazine articles were written by employees of equipment manufacturers, and this is indicated in the text. David Mills, *Pneumatic Conveying Design Guide*, 2nd edition (Elsevier/Butterworth-Heinemann, 2004) is cited with printed book page numbers; the 3rd edition of the book was published in 2015/2016 (ISBN 978-0-08-100649-8), and whether the values changed in that edition has not been checked. All Mills page numbers are the printed page numbers of the book and have been verified one by one against the page headers. Manufacturer documents such as the Ferlin MOVAC operating manuals and the Michel Tube catalog were obtained from companies that Teknik Part represents; the statements in these documents are likewise manufacturer information; in the Ferlin and Michel Tube documents, page numbers are the printed page numbers of the document. The resin producer limits in the quality section (DuPont, Covestro) were read from the PDF pages of the processing guides published by the producers; page numbers are PDF pages. Secondary claims of unclear origin about moisture uptake rates, and general scrap improvement cases that cannot be attributed to the material system, have deliberately not been used. Project proposals and customer documents have not been used in this study.

TEKNIK PART

Teknik Part's solutions in this field

Teknik Part offers products from the brands it represents in the following links of the chain discussed in this report. **Ferlin MOVAC**: machine-side self-contained loaders (MOVAC Easy), machine-mounted vacuum receivers for central systems, vacuum pumps, central filter units, distribution tables and coupling stations. **Michel Tube**: stainless, aluminum, wear-resistant and borosilicate glass pipes and bends (with different bend radius options), pipe and hose couplings, conveying hoses, suction lances, material distributors, color coding, and in-line magnetic and all-metal separators. **Mensink**: magnetic separators. **Ferlin EasyDry and Digicolor**: raw material drying systems; **Digicolor** also granulators. **Ferlin GRAVIMIX**: machine-mounted gravimetric dosing systems. For the technical data of these products, the relevant product pages and manufacturer datasheets should be consulted; the general engineering findings in this report are not performance claims for any particular product.

CONCLUSION

Conclusion

The most important conclusion of this study is that in central conveying both efficiency and quality are not a property of the equipment but a discipline of **setting, closedness and maintenance**. On the efficiency side, the numerical evidence is strongest where the physics textbook and independent engineering sources speak: the velocity band, the exponential dependence of wear on velocity, the multiplication of velocity along the line under vacuum, the weight of bends in the equivalent length and the cost of compressed air. On the quality side, by contrast, the strongest evidence comes not from equipment manufacturers but from resin producers: the moisture limit, the requirement for closed conveying, moisture uptake on a scale of minutes in an open hopper and the limits on the regrind ratio are in the raw material's own datasheet. This changes the justification for an investment in central conveying. Defending the move from machine-side loaders to a central system with an energy percentage means leaning on a manufacturer figure with no independent measurement; defending the same move with the sentence "the resin producer requires closed conveying, yet we leave dried material standing in an open container" means leaning on a verifiable specification.

The second conclusion is that efficiency and quality constrain each other within the same chain. The pump's time budget calls for larger receivers, while the moisture sensitivity of dried material calls for smaller ones; line purging protects quality but can cut capacity by up to half; a large drying hopper secures capacity but overdries; increasing regrind saves raw material but carries fines and ratio deviation into quality. Good design resolves these conflicts material by material: on lines using hygroscopic, blended and low-ratio masterbatch material it gives priority to quality, and for high-volume material that needs no drying, to capacity; and it builds the move from a machine-side arrangement to a central system not in a single step but in stages, starting with the most sensitive material. The biggest gap in this field is the absence of measured data from plants in Turkey: once the residual moisture at the feed throat, the fines content in regrind, the receiver fill time and kWh per ton have been measured even once in a few real plants, they will form a basis for comparison more valuable than most of the sources of this report.

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