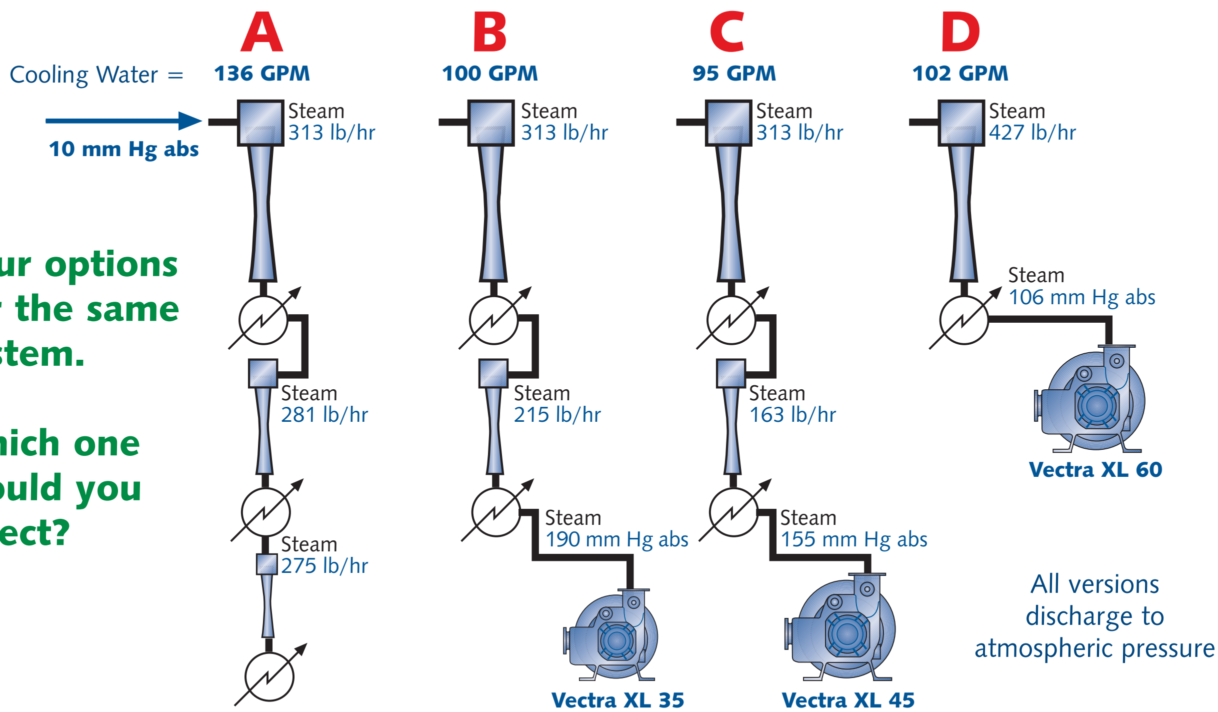
Steam Ejector Hybrid Systems in the Chemical Industry

Nash can help you cut the energy costs of your ejector systems. Use Nash's experience with pumps and ejectors to optimize your system. The payback may surprise you!



Four options for the same system.

Which one would you select?

Option A	Option B	Option C	Option D
Steam = 869 lb/hr	**Steam = 528 lb/hr**	**Steam = 476 lb/hr**	**Steam = 427 lb/hr**
(869) ($8) (8000 hr/yr) / 1000 lb	(528) ($8) (8000 hr/yr) / 1000 lb	(476) ($8) (8000 hr/yr) / 1000 lb	(427) ($8) (8000 hr/yr) / 1000 lb
= $55,616/yr	**= $33,792/yr**	**= $30,464/yr**	**= $27,328/yr**
	Power = 8.5 bhp (6.3 KWH)	**Power = 11.5 bhp (8.6 KWH)**	**Power = 23.4 bhp (17.5 KWH)**
	(6.3) ($.08) (8000 hr/yr) / 88% efficiency	(8.6) ($.08) (8000 hr/yr) / 88% efficiency	(17.5) ($.08) (8000 hr/yr) / 88% efficiency
	= $4612/yr	**= $6,239/yr**	**= $12,696/yr**
Operating Cost **$55,616**	**Operating Cost** **$38,404**	**Operating Cost** **$36,703**	**Operating Cost** **$37,073**
Equipment Investment **$59,380**	**Equipment Investment** **$67,900**	**Equipment Investment** **$70,272**	**Equipment Investment** **$67,760**

Assumptions

100 lb/hr of air plus 20 lb/hr of water vapor	**Steam cost, $8/1,000 lb**
10 mm Hg abs	**Power cost, 8¢/KWH**
100 PSIG steam and 85°F Cooling Water	**Time base, 8,000 hr/yr**

The final choice will depend on your company's objectives

Evaluation of a system is a function of factors determining the method of evaluation. There are different ways of evaluating a system.

1) Low price
2) Initial investment
3) Payback time
4) Energy savings or scarcity on steam in the plant

Installation and maintenance costs must be considered in the whole equation. For example, an all-ejector system will have the lowest equipment cost but when you add the cost of installation, it may make the system more expensive than a hybrid system. Further, all-ejector systems are less forgiving of any deviation to design conditions and excessive back pressure may make the system unstable.

A three stage hybrid system may give the best payback time, but installation costs will still be higher because the first inter-condenser must be installed at an elevation allowing it to gravity drain the condensate - but the system will provide stable performance and is not susceptible to excessive back pressure.

A two stage hybrid may not give the best return, but will cut down the installation cost since condensate from first inter-condenser can drain into the vacuum pump, so there is no need to elevate the condenser. Elimination of a second inter-condenser and a second stage ejector may bring the initial cost down. It is a stable system, is forgiving of inter-condenser performance and uses minimum amounts of steam and cooling water.

A quick scan of the curves reveals that option D can be ruled out based on higher annual operating cost, higher first year cost and higher four-year cost, unless you have a need to minimize steam consumption in addition to saving on installation cost. In a two stage hybrid system, condensed vapor can be drained into the vacuum pump eliminating the need to elevate the condenser's or provide additional equipment like low NPSH pump.

Capital Costs

A $59,380
B $67,900
C $70,292
D $67,760

When low initial cost is the primary objective, an all-jet system always comes in first. In this case, the capital cost for option D is more attractive than options B and C and this option will always have minimum installation cost.

Payback Time

A base
B 5.9 months
C 6.9 months
D 6.5 months

The additional cost of option B or C will be payed back in 5.9 to 6.9 months.

Annual Operating Cost

	Steam	Electricity	Total
A	$55,616	$0	$55,616
B	$33,722	$4,612	$38,404
C	$30,484	$6,239	$36,703
D	$27,328	$12,696	$40,024

Although option B yields a faster payback, option C comes in first on the basis of annual operating cost alone.

First-Year Total Cost

A $59,380 + $55,616 = $114,996
B $67,900 + $38,404 = $106,304
C $70,292 + $36,703 = $106,995
D $67,760 + $40,024 = $107,784

Here, annual operating costs have been added to the corresponding equipment costs. Options B and C are virtually identical.

Four-Year Cost

A $281,844
B $221,516
C $217,104
D $227,856

This ranking may apply more closely to your company's objectives than any of the others. Option C saves enough, compared with option B, to justify its slightly higher initial cost. If utility costs should rise due to inflation, option C's margin of preference would widen.

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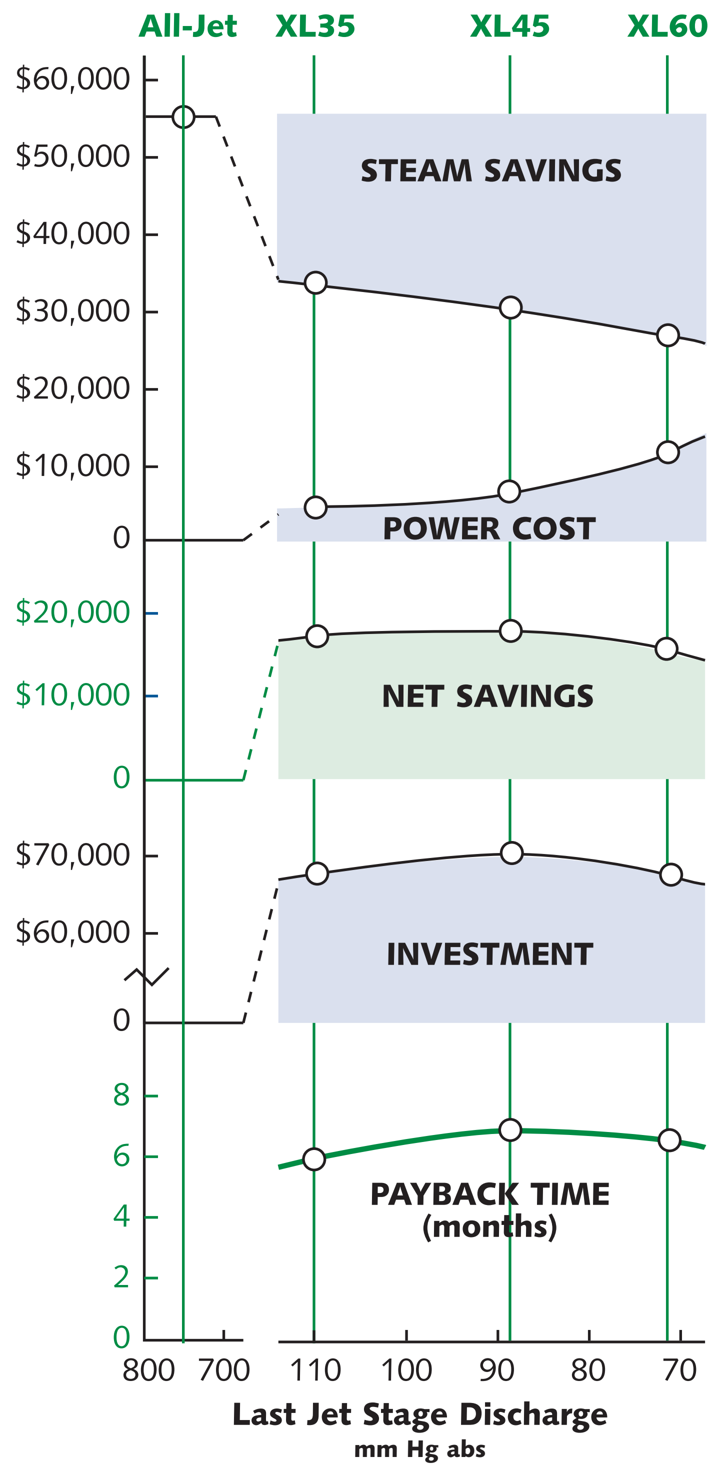
These curves are plotted against pump inlet vacuum, which is the discharge pressure of the last jet stage. This interface pressure marks the division of work - how much is done by steam jet ejectors and how much by the vacuum pump.



Reduce Steam Consumption

Options B,C and D all cut steam consumption significantly. Steam savings increase as more pump capacity is added.

Increase Power Consumption

Power consumption increases with pump size.

Save the Difference

Subtracting the total steam and power costs of options B, C and D from the steam costs of the all-jet system, option A, shows that savings peak near option C. If savings due to cooling water usage and effluent treatment are added, savings would be more significant.

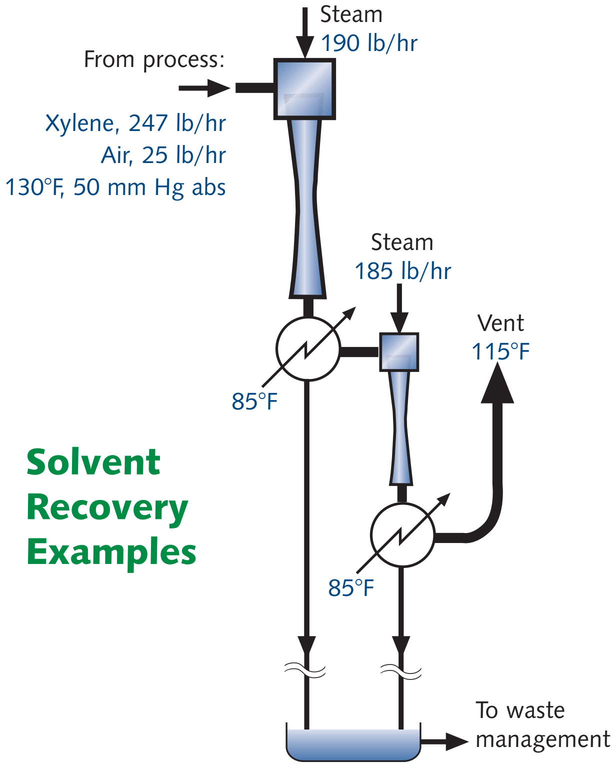
Add up Equipment Cost

The shaded area represents additional equipment investment required to gain the savings shown on the curve above. Case D equipment cost is lower than case B and C due to the elimination of second stage ejector and second inter condenser.

Look at Payback Time

This plot of investment increment divided by annual savings shows payback time in months.

Solvent Recovery Examples



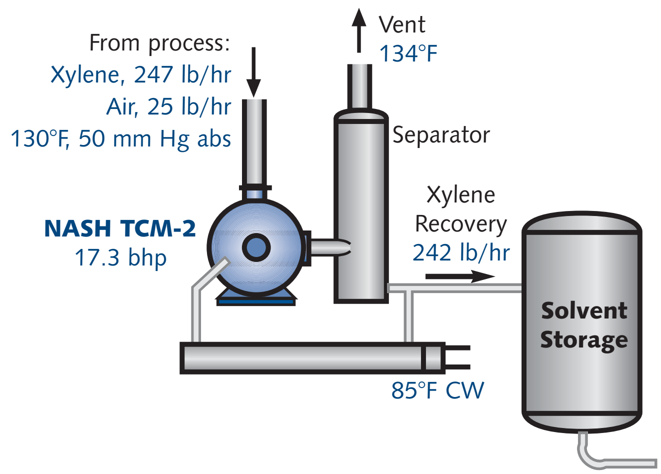
Jet Ejector System

Steam, 375 lb/hr

$$\frac{(375\ \text{lb/hr})\ (\$8)\ (8{,}000\ \text{hr/yr})}{(1{,}000\ \text{lb})}$$

= $24,000/yr

Diluted xylene to waste treatment, 244 lb/hr



NASH Vacuum System

Power, 17.3 bhp

$$\frac{(17.3\ \text{bhp})\ (.746)\ (\$.08)\ (8{,}000\ \text{hr/yr})}{88\%\ \text{efficiency}}$$

= $9,386/yr

Recovered xylene, 242 .b/hr
Product value @ 10¢/lb
(242 lb/hr) ($.10/lb) (8,000 hr/yr)
= $193,600/yr

Operating Savings	**$14,614/yr**
Recovery Savings	**$193,600/yr**
Total Savings	**$208,214/yr**

Product Recovery Speeds Payback

When a valuable component of the mixture evacuated from your process can be reclaimed in the vacuum system, don't pollute it with a steam jet ejector. Product recovery in an all-pump system can have an extremely short payback period. The example here depicts a replacement for jets handling air and xylene.

In an all-jet system, xylene vapor was polluted with steam condensate. Valuable condensed xylene was either lost to waste treatment or else had to be recovered at considerable expense by additional processing.

The Nash vacuum pump uses recirculated liquid xylene as its compressant. Xylene vapors are simply condensed in the pump and drawn off for reuse or sale. The required vacuum level in this example is 50 mm Hg abs, which is well within the capability of a two-stage Nash vacuum pump sealed with xylene and cooled by 85°F water to in its heat exchanger.

The value of the recovered xylene dwarfs the energy savings. No attempt was made here to calculate savings in the waste treatment load but they, too, could be significant.

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APP-1086B-0712