UNIQUE SYSTEMS®
INCORPORATED
ONE SADDLE ROAD - CEDAR KNOLLS, NEW JERSEY 07927-1998
Phone 973-455-0440 Fax 973-455-7214

HEAT EXCHANGE INSTITUTE INCORPORATED MEMBER

EJECTOR AIR REMOVAL SYSTEMS – ENGINEERING DATA

GENERAL

Air Removal Systems generally consist of dual 100% (twin-element) ejectors, single 100% surface-type inter- & aftercondensers, suction & discharge isolation valves for each stage and interconnecting vacuum piping. These systems are designed to meet Heat Exchange Institute (HEI) and specific industry standard requirements as follows:

- **HEI Requirements**

  Air removal ejectors designed to meet HEI specified requirements must handle the HEI recommended air leakage, saturated with water vapor at 1" Hg Abs and 7½°F below the operating temperature of the condenser served by the ejector. These systems as described above are arranged to allow operation with one spare set of ejector stages, installed and ready to operate.

- **Industry Standard Requirements**

  Air removal ejectors designed to meet industry standards should handle the air leakage specified, saturated at the operating pressure and 7½°F below the operating temperature of the condenser served by the ejector. If air leakage is not specified, use the HEI recommended value but not the HEI recommended operating pressure of 1" HgA. Size for 1" Hg below the design operating pressure. Single-element units are available.

STANDARD MATERIALS OF CONSTRUCTION

EJECTORS		INTERCONNECTING VACUUM PIPING	
Steam Chest:	Carbon Steel	**Pipe & Fittings:**	Carbon Steel
Steam Nozzle:	303SS	**VACUUM VALVES (Butterfly-Type)**	
Suction Chamber:	Carbon Steel	**Body / Disc:**	Nodular / Cast Iron
Diffuser:	Carbon Steel	**Elastomers:**	Buna
CONDENSERS		**STEAM PIPING**	
Shell:	Carbon Steel	Steam piping, valves & strainers are suitable for the design motive pressure and temperature of system motive steam supply. Standard is Sch. 80 pipe (A106) with 3,000# fittings and 800# class valves (A105).	
Water Boxes:	Carbon Steel		
Tube Sheets:	Carbon Steel		
Tubes:	304LSS		
Baffles:	Carbon Steel		

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Large steam condensers serving turbines require air removal equipment to maintain the vacuum on the main condenser. The design characteristics of air removal equipment are outlined in the Heat Exchange Institute "Standards for Steam Surface Condensers".

Unique Systems has combined the requirements of HEI with customer specifications and has developed standard air removal equipment with both single- & twin-element ejector systems to serve commercial and power industry requirements.

In addition to the air removal ejector needed to maintain a vacuum on the condenser, a rapid evacuation (hogger) single-stage ejector is usually required during start-up to remove air from the turbine, piping and condenser shells. In cases where start-up steam is not available, common with combined-cycle power systems, consult with Unique Systems for information on alternatives including liquid ring vacuum pump hogger exhausters.

SELECTION PROCEDURE

How to properly select single- or twin-element ejector systems for air removal service is demonstrated in the example that is presented with the tables described below.

TABLE 1 – Lists the HEI air leakage quantities corresponding to the given steam flow, ejector sizes and steam requirements for various condenser pressures. Twin-element systems require two ejectors of each size in the chosen system.

TABLE 2 – Lists the properties of inter- & aftercondensers used on single-element air removal ejector packages. For air removal capacities of 3 – 7.5 SCFM, a choice of separate or combined shells for inter- & aftercondensers is available.

TABLE 3 – Lists the properties of inter- & aftercondensers used on twin-element air removal ejector packages. Limited choices of separate or combined shell for the condensers are available.

TABLE 4 – Lists evacuation data for hogger ejectors. Non-standard hoggers sized for volume and evacuation time are also available.

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SELECTION PROCEDURE (EXAMPLE)

Select Twin-Element Air Removal Package to serve a condenser using the following criteria…

Condenser Steam Flow:	20,000 #/Hour
Motive Steam Pressure:	100 PSIG (Dry & Saturated)
Ejector Design Suction Pressure:	1" Hg Abs
Unit Size (Table 1):	31C11C Twin-Element
Steam Consumption (Table 1):	180 #/Hour per Element
Intercondenser Surface Area (Table 3):	60 Ft² or 53 Ft² (Alternate)
Aftercondenser Surface Area (Table 3):	20 Ft² or 24 Ft² (Alternate)
*** Water Consumption:**	40 GPM
Intercondenser Water Velocity:	1.15 Feet/Second
Aftercondenser Water Velocity:	1.73 Feet/Second
Alternate Intercondenser Water Velocity:	0.65 Feet/Second
Alternate Aftercondenser Water Velocity:	1.47 Feet/Second

* Note: This example is based upon using cooling water for the inter- & aftercondensers. Please consult Unique Systems for systems using condensate as the cooling medium.

TABLE 1: AIR LEAKAGE RATES

HEI STEAM FLOW LIMITS (#/Hour)	HEI LEAKAGE RATE (SCFM) 70°F Air	CONDENSER PRESSURE (Inches Hg Abs)	NOMINAL STEAM CONSUMPTION PER ELEMENT (#/Hour) 100 PSIG Steam *	SIZE
0 to 25,000	3	1.0	180	31C11C
		1.5	160	23C11C
		2.0	145	23C11C
		2.5	130	23C11C
		3.0	120	15C11C
		3.5	110	15C11C
		4.0	105	15C11C
25,001 to 50,000	4	1.0	240	32C11C
		1.5	215	31C11C
		2.0	190	23C11C
		2.5	175	23C11C
		3.0	160	23C11C
		3.5	150	23C11C
		4.0	140	23C11C
50,001 to 100,000	5	1.0	300	32C11C
		1.5	265	32C11C
		2.0	240	31C11C
		2.5	220	23C11C
		3.0	200	23C11C
		3.5	190	23C11C
		4.0	170	23C11C
100,001 to 250,000	7.5	1.0	450	42C15C
		1.5	400	41C15C
		2.0	360	32C15C
		2.5	325	32C15C
		3.0	300	31C15C
		3.5	280	31C15C
		4.0	260	23C15C
250,001 to 500,000	10	1.0	600	61C15C
		1.5	530	42C15C
		2.0	480	41C15C
		2.5	435	32C15C
		3.0	405	32C15C
		3.5	375	31C15C
		4.0	345	31C15C

* Please consult Unique Systems for steam pressures other than 100 PSIG.

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TABLE 2: SINGLE-ELEMENT SURFACE-TYPE INTER- & AFTERCONDENSERS

Size HEI Leakage (SCFM)	3		4		5		7.5		10
Comments	Separate Shells	Combined Body	Separate Shells	Combined Body	Separate Shells	Combined Body	Separate Shells	Combined Body	Separate Shells
Intercondenser Surface (Ft^2)	30	53	43	53	43	53	60	53	90
Intercondenser No. Shell Ø (In.)	1 9¼	3 9¼	1 9¼	3 12½	1 9¼	3 12½	2 12½	3 12½	2 12½
Aftercondenser Surface (Ft^2)	10	24	15	24	15	24	20	24	30
Aftercondenser No. Shell Ø (In.)	1 9¼	---	1 9¼	---	1 9¼	---	1 9¼	---	1 9¼
Intercondenser Tube Count	51	90	74	90	74	90	103	90	154
Aftercondenser Tube Count	17	40	25	40	25	40	34	40	51
Min. Water Flow (GPM)	18	18	25	25	50	50	125	125	250
Max. Water Flow (GPM)	62.5	62.5	125	125	250	250	625	725	1,250
Intercondenser # Water Passes	2	1	2	1	2	1	2	1	2
Aftercondenser # Water Passes	1	1	1	1	1	1	1	1	1

GPM = $\frac{\text{Steam Flow to Main Condenser (\#/Hour)}}{500}$

TABLE 3: TWIN-ELEMENT SURFACE-TYPE INTER- & AFTERCONDENSERS

Size HEI Leakage (SCFM)	3		4	5	7.5	10
Comments	Separate Shells	Combined Body	Separate Shells	Separate Shells	*	*
Intercondenser Surface (Ft^2)	60	53	75	85	120	180
Intercondenser No. Shell Ø (In.)	2 12½	3 12½	2 12½	2 12½	*	*
Aftercondenser Surface (Ft^2)	20	24	25	30	45	60
Aftercondenser No. Shell Ø (In.)	1 9¼	----	1 9¼	1 9¼	*	*
Intercondenser Tube Count	102	90	128	145	*	*
Aftercondenser Tube Count	34	40	43	51	*	*
Min. Water Flow (GPM)**	18	18	28	50	125	250
Max. Water Flow (GPM)	62.5	62.5	125	250	625	1,250
Intercondenser # Water Passes	2	1	2	1	*	*
Aftercondenser # Water Passes	1	1	1	1	*	*

* Information for 7.5 & 10 SCFM systems and larger can be obtained from Unique Systems for specific applications.
** Based upon using cooling water for inter- & aftercondensers. Designs using condensate as cooling medium also available.

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TABLE 4: EVACUATOR DATA (HOGGER EJECTORS)

HEI STEAM FLOW LIMITS (#/Hour)	EVACUATOR DATA		
	Capacity (#/Hour) Air at 15" Hg Abs	Steam Consumption (#/Hour) 100 PSIG Steam *	Ejector Size
0 – 75,000	675	825	31E
75,001 – 250,000	1,350	1,650	42E
250,001 – 750,000	2,700	3,300	61E
750,001 – 2,000,000	4,050	4,940	62E
2,000,001+ Higher	5,550	6,700	8" x 8"

* Please consult Unique Systems for steam pressures other than 100 PSIG.

Non-standard hoggers sized for volume and evacuation time are also available.

If steam is not available during plant start-up, consult Unique Systems for alternatives including liquid ring vacuum pump hoggers.