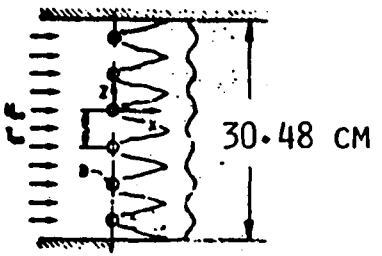
NASA DILUTION JET MIXING - PHASE I

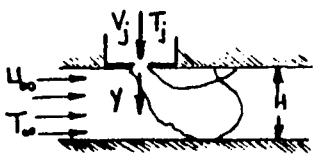
OBJECTIVE:

- o COLLECT A DATA BASE ON MIXING OF A ROW OF JETS WITH A CONFINED CROSS FLOW
- o DEVELOP EMPIRICAL JET MIXING CORRELATIONS

PARAMETERS INVESTIGATED:

- o MOMENTUM RATIO (J), H/D, S/D, ρ_j/ρ_∞
- o NON-UNIFORM CROSS-STREAM TEMPERATURE AND VELOCITY PROFILES
- o COLD/HOT JET INJECTION
- o CROSS-STREAM FLOW AREA CONVERGENCE





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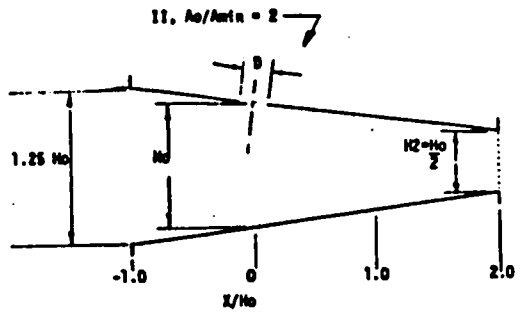
PHOENIX, ARIZONA

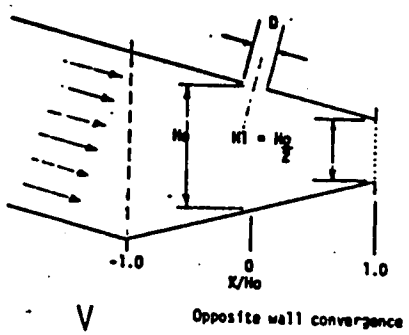
S. Srinivasan
Garrett Turbine Engine Company
Phoenix, Arizona

PHASE 1 TEST SECTION CONFIGURATIONS

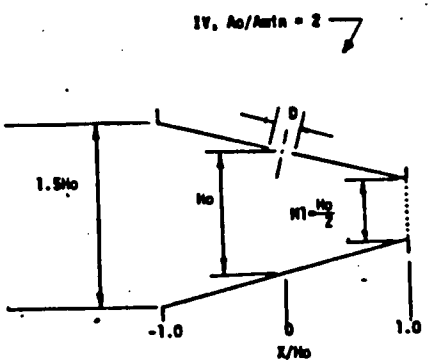
TEST SECTIONS:

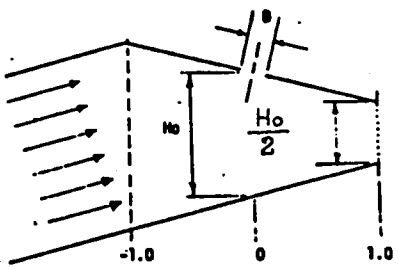
H_0 = 10.16 cm





V Opposite wall convergence





VI Injection wall convergence

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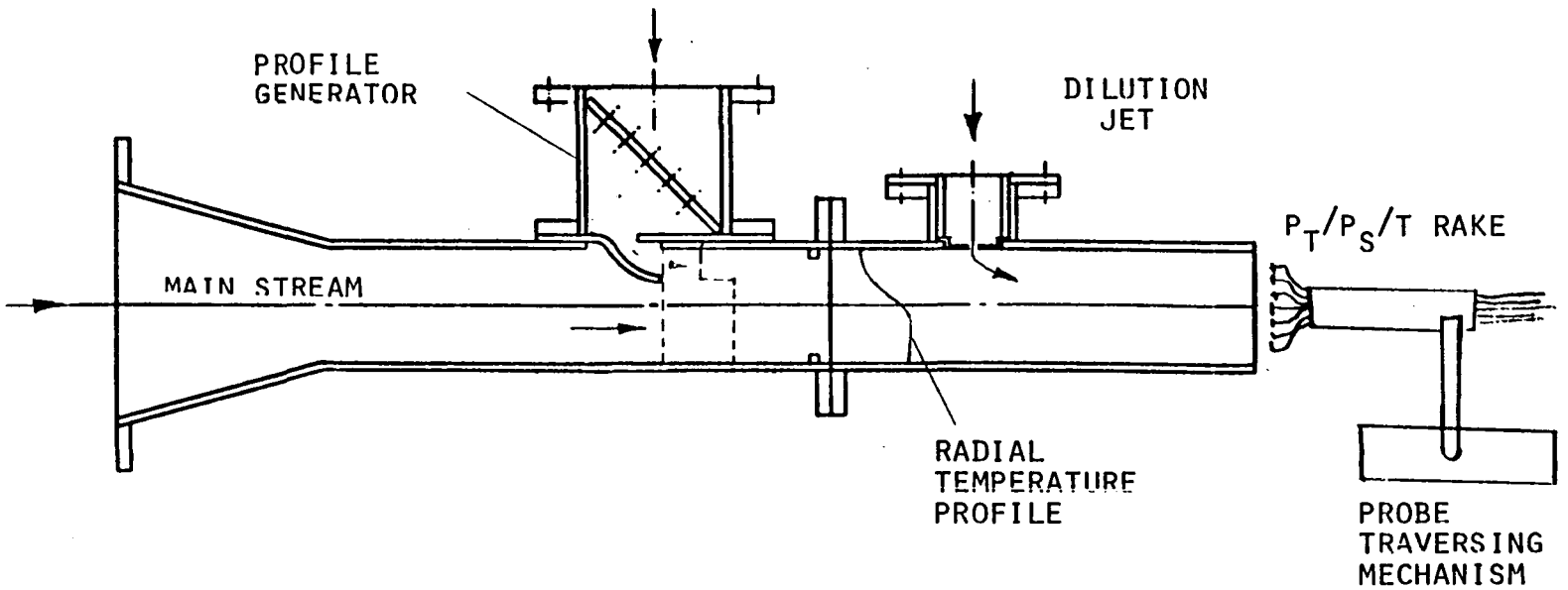
SCHMEMATIC OF THE DILUTION JET MIXING TEST RIG



NASA DILUTION JET MIXING - PHASE II

OBJECTIVE:

- EXTEND THE DATA BASE ON MIXING OF SINGLE-SIDED ROW OF JETS WITH A CONFINED CROSS FLOW.
- COLLECT DATA BASE ON MIXING OF TWO-SIDED ROW OF JETS WITH A CONFINED CROSS FLOW
- DEVELOP EMPIRICAL JET MIXING CORRELATIONS

PARAMETERS INVESTIGATED:

- CIRCULAR VS SQUARE ORIFICES, TWO-DIMENSIONAL SLOT
- MOMENTUM RATIO (J), H/D, S/D
- IN-LINE AND STAGGERED ORIFICE CONFIGURATIONS
- NON-UNIFORM CROSS-STREAM TEMPERATURE AND VELOCITY PROFILES
- CORSS-STREAM FLOW AREA CONVERGENCE

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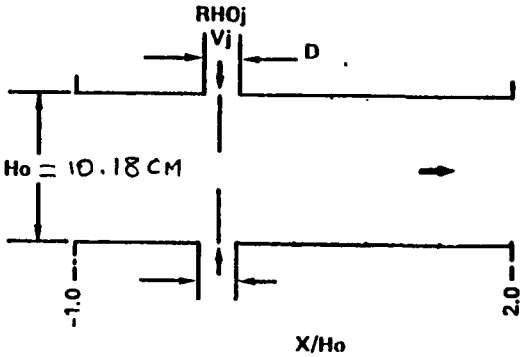
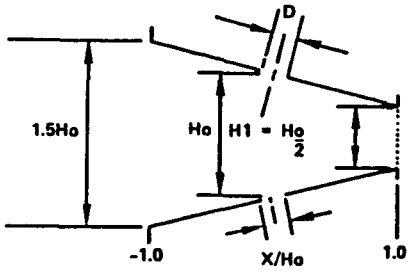
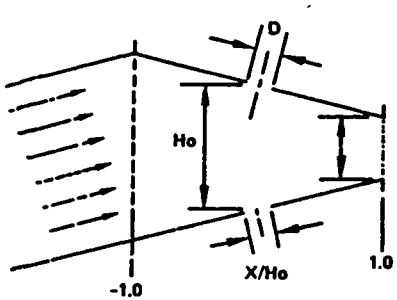
PHASE II TEST SECTIONS AND ORIFICE CONFIGURATIONS



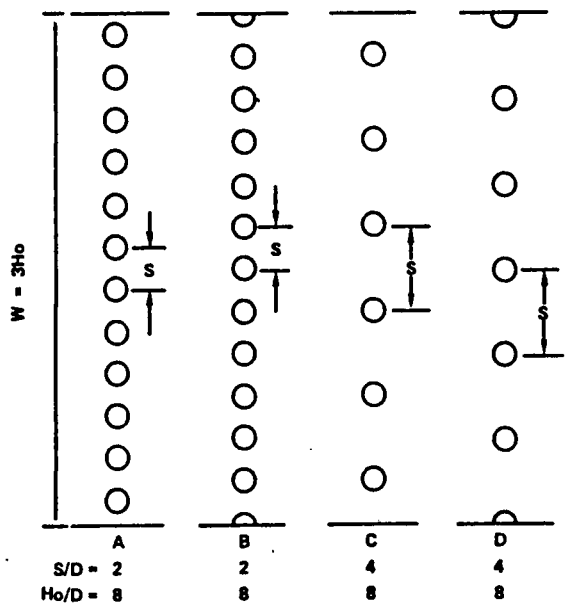


SYMMETRIC CONVERGENCE



ASYMMETRIC CONVERGENCE

Test Sections

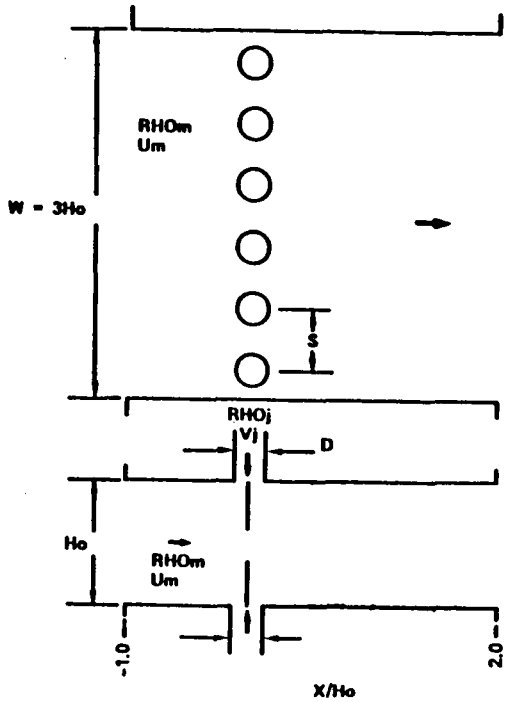


Orifice Configurations.

PHASE II SERIES 1 TESTING

SCOPE

- COMPARE EFFECTS OF J, S/D, H/D
  - TWO-SIDED AND ONE-SIDED JET INJECTION
  - IN-LINE AND STAGGERED ORIFICE CONFIGURATIONS
- DEVELOP CORRELATIONS FOR TWO-SIDED JET INJECTION



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PHASE II SERIES 1 TEST CONDITIONS

U_M = 15 M/S T_M = 645°K H_o = 10.16 CM

H/D	S/D	CONFIGURATION	J_{TOP}	J_{BOTTOM}
8	2	IN-LINE	6.81	6.88
		INJECTION	25.0	24.8
			101.8	101.9
	2	STAGGERED	6.53	6.54
		INJECTION	25.2	24.7
			99.3	99.6
	4	IN-LINE	7.85	7.81
		INJECTION	27.9	27.3
			108.3	107.0
	4	STAGGERED	5.98	6.14
		INJECTION	25.7	25.7
			103.1	104.3

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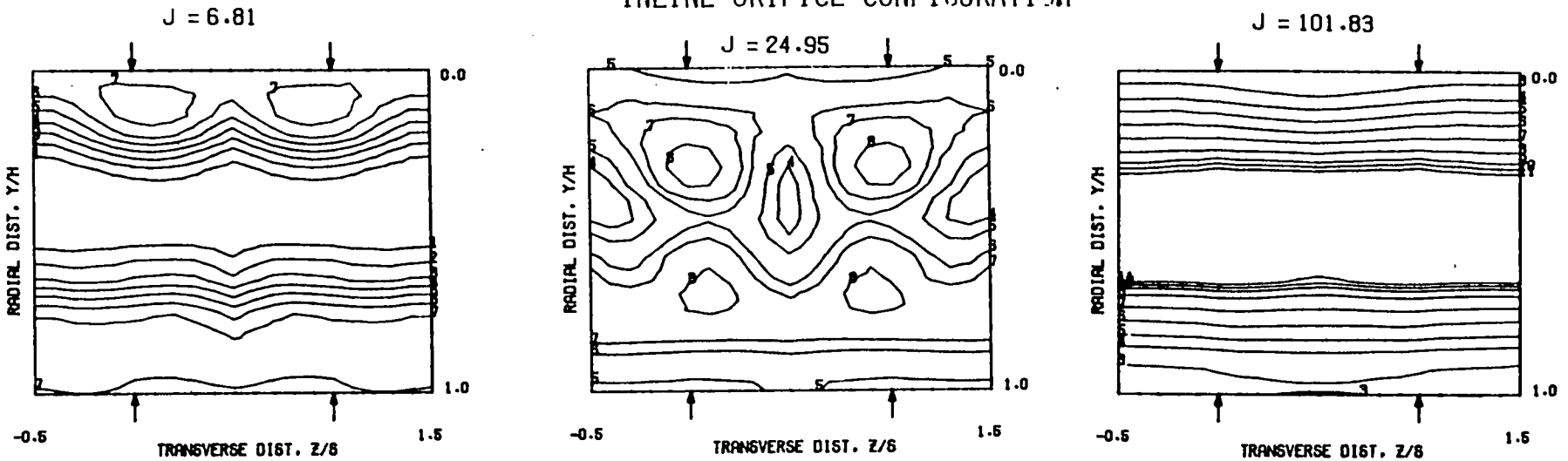
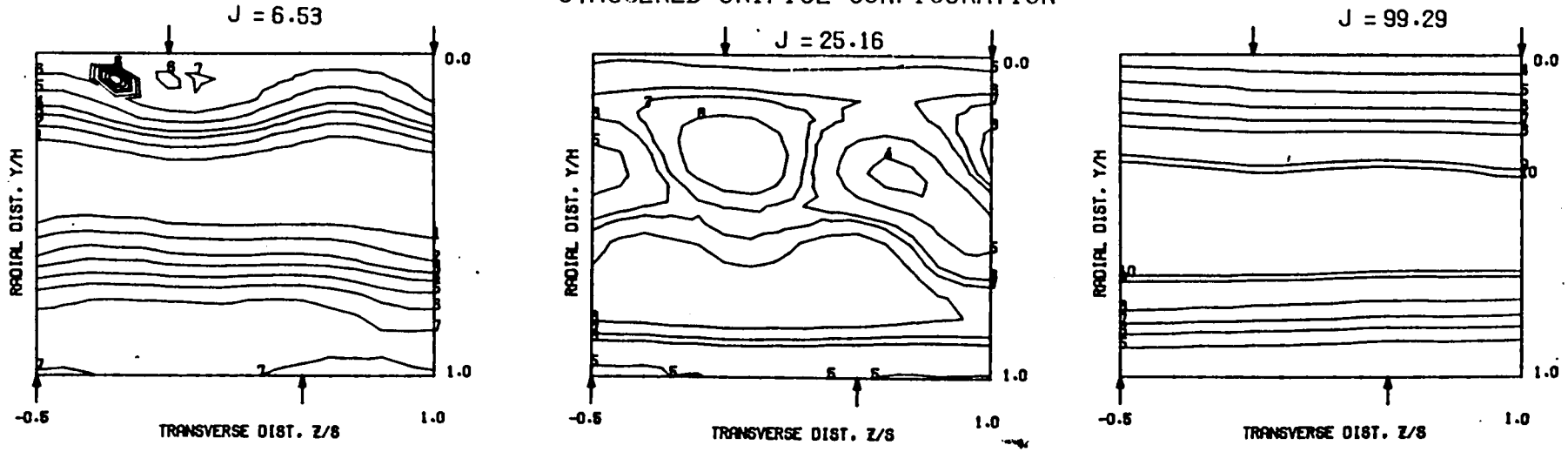
MEASURED THETA DISTRIBUTIONS FOR S/D = 2, H/D = 8, X/Ho = 0.5

INLINE ORIFICE CONFIGURATION



STAGGERED ORIFICE CONFIGURATION



$$\theta = (T_M - T)/(T_M - T_J)$$

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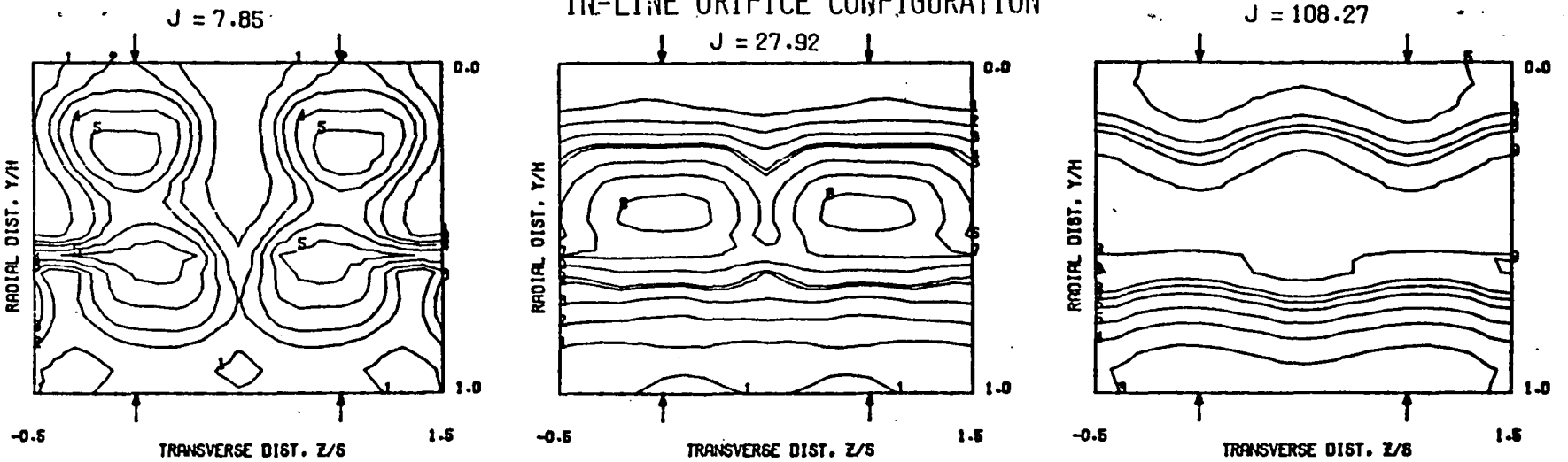
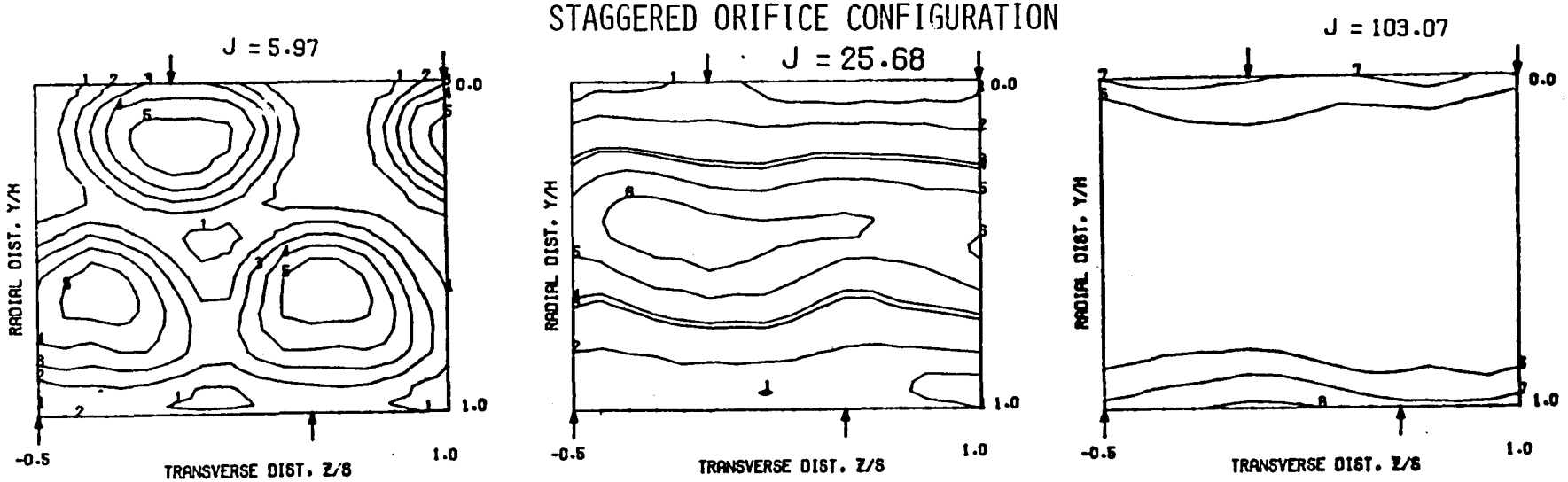
MEASURED THETA DISTRIBUTIONS FOR S/D = 4, H/D = 8, X/Ho = 0.5

IN-LINE ORIFICE CONFIGURATION



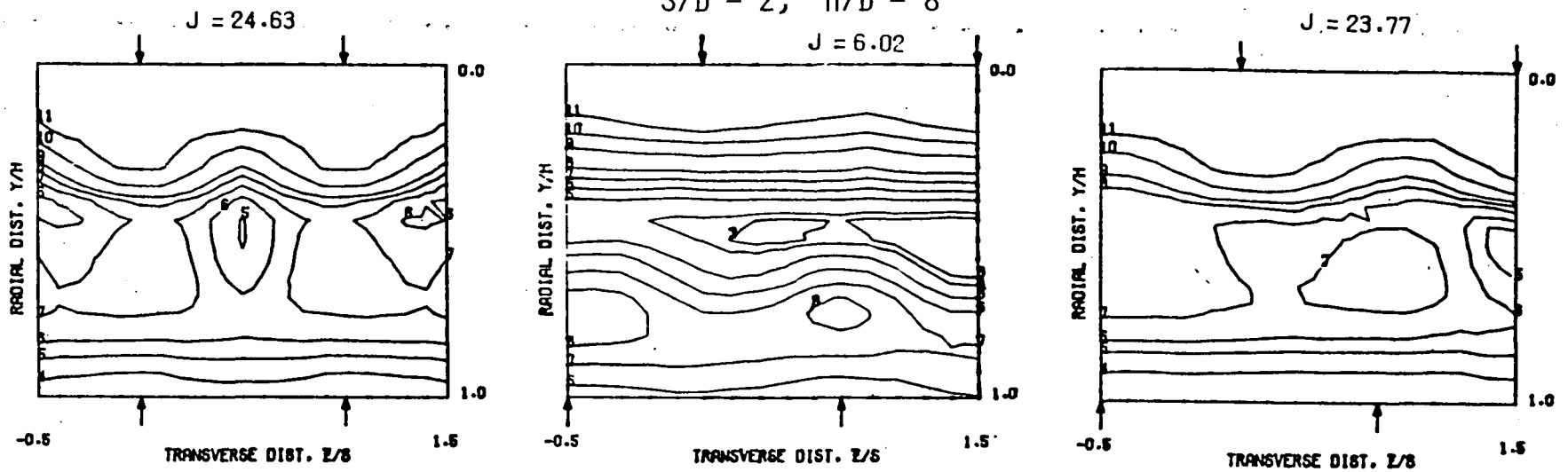
STAGGERED ORIFICE CONFIGURATION

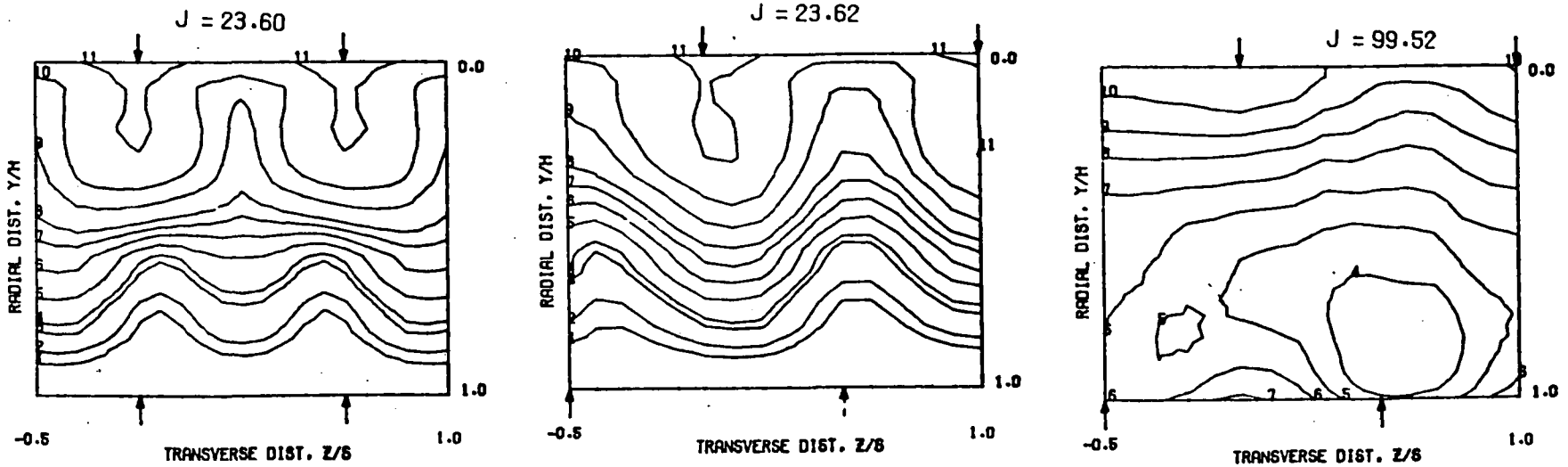


$$\theta = (T_M - T)/(T_M - T_J)$$

MEASURED THETA DISTRIBUTION FOR PROFILED MAINSTREAM

S/D = 2, H/D = 8





S/D = 4, H/D = 8

$\theta = (T_{MAX} - T)/(T_{MAX} - T_J)$

PHASE II SERIES 2 TESTS

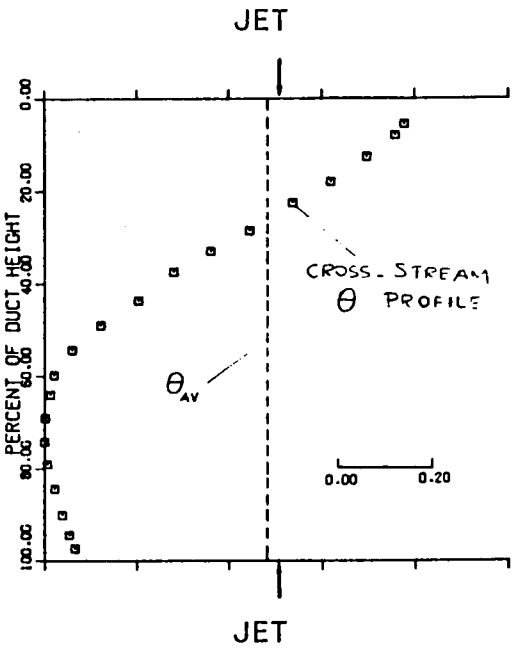
SCOPE:

- TWO-SIDED JET INJECTION WITH PROFILED CROSS-STREAM

TEST CONDITIONS:

U_M = 15 M/S H = 10.16 CM, T_J = 300°K

H/D	S/D	CONFIGURATION	J_{TOP}	J_{BOTTOM}
8	2	IN-LINE	24.6	24.7
		STAGGERED	6.02	6.21
		STAGGERED	23.8	23.4
8	4	IN-LINE	23.6	24.2
		STAGGERED	23.6	24.1
		STAGGERED	99.5	99.3



$\theta = (T_{MAX} - T)/(T_{MAX} - T_J)$

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FUTURE TEST PLAN ON PHASE II

- ONE-SIDED JET INJECTION
  - TWO - DIMENSIONAL SLOT
  - SQUARE HOLES
- TWO-SIDED JET INJECTION
  - NON-UNIFORM CROSS-STREAM TEMPERATURE PROFILES
  - UNEQUAL JET INJECTION RATES
  - CONVERGENT TEST SECTIONS (SYMMETRIC AND ASYMMETRIC)

SCHEDULED COMPLETION DATE ON PHASE II TESTS: DECEMBER 1982

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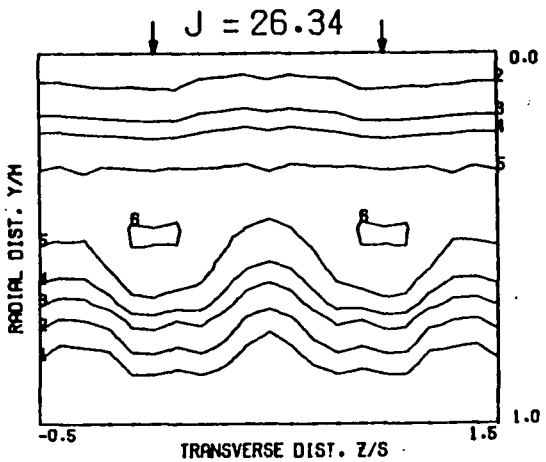
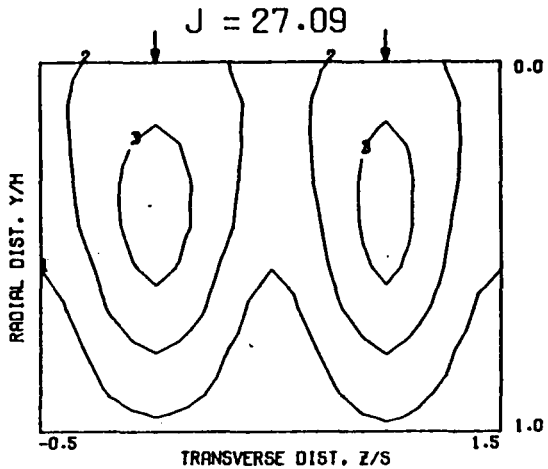
MEASURED THETA DISTRIBUTIONS WITH FLOW AREA CONVERGENCE FOR S/D = 4, H/D = 8 AT X/8 = 1

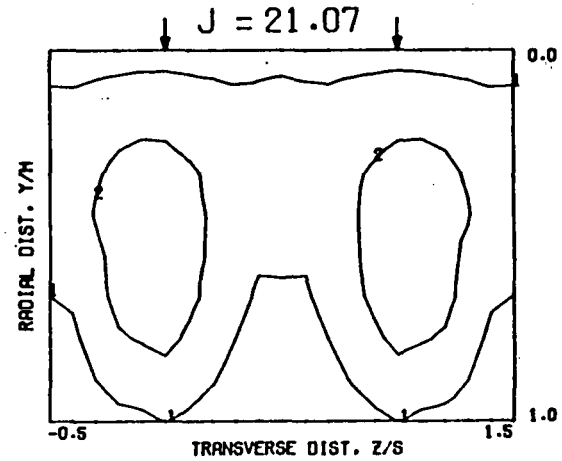
ϕ = 90°, A_1/A_2 = 1



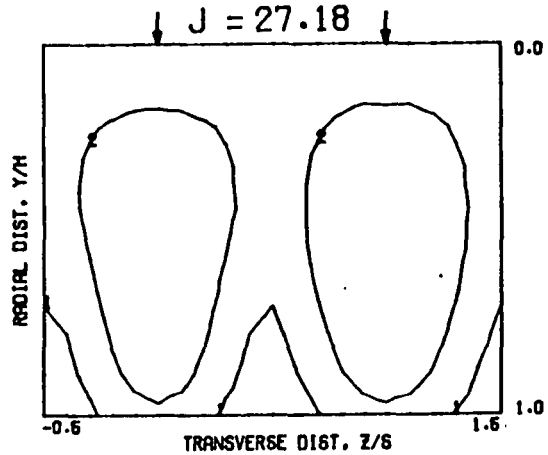
ϕ = 97°, A_1/A_2 = 1.33



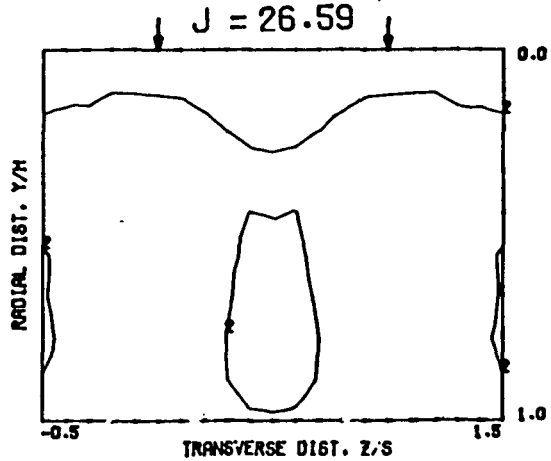
ϕ = 104°, A_1/A_2 = 2



ϕ = 90°, A_1/A_2 = 2



ϕ = 117°, A_1/A_2 = 2



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COMPARISON BETWEEN ONE-SIDED AND TWO-SIDED JET INJECTION

S/D = 2, H/D = 8

PARAMETER	M_{JET}/M_{MAIN}	TWO-SIDED INJECTION IN-LINE	TWO-SIDED INJECTION STAGGERED	ONE-SIDED INJECTION H/D = 8	ONE-SIDED INJECTION H/D = 4
MOMENTUM RATIO, J	0.23	6.81	6.53	25.3	5.74
$\theta_{EB} = (T_M - T_{EB})/(T_M - T_J)$		0.198	0.189	0.169	0.176
MAX JET PENETRATION, Yc/H		0.2	0.19	0.40	0.36
JET HALF WIDTH, $W_{\frac{1}{2}}^{+}/H$, AT X/H = 1		0.33	0.25	0.28	0.20
JET HALF WIDTH, $W_{\frac{1}{2}}^{-}/H$, AT X/H = 1		0.0	0.0	0.12	0.13
θ/θ_{EB} AT X/H = 1		1.82	1.94	1.89	2.06
MOMENTUM RATIO, J	0.47	25.0	25.2	107.8	22.0
$\theta_{EB} = (T_M - T_{EB})/(T_M - T_J)$		0.318	0.319	0.302	0.271
MAX JET PENETRATION, Yc/H		0.35	0.35	0.66	0.60
JET HALF WIDTH $W_{\frac{1}{2}}^{+}/H$ AT X/H = 1		0.	0.	0.19	0.24
JET HALF WIDTH, $W_{\frac{1}{2}}^{-}/H$ AT X/H = 1		0.2	0.28	0.26	0.27
$\theta c/\theta_{EB}$ AT X/H = 1		1.08	1.10	1.17	1.44

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COMPARISON BETWEEN ONE-SIDED AND TWO-SIDED JET INJECTION

S/D = 4, H/D = 8

PARAMETER	M_{JET}/M_{MAIN}	TWO-SIDED INJECTION		ONE-SIDED INJECTION	
		IN-LINE	STAGGERED	H/D = 8	H/D = 4
MOMENTUM RATIO, J	0.125	7.85	5.97	26.3	6.14
$\theta_{EB} = (T_M - T_{EB})/(T_M - T_J)$		0.112	0.102	0.105	0.107
MAX JET PENETRATION, Yc/H		0.37	0.24	0.54	0.54
JET HALF WIDTH, $W_{\frac{1}{2}}^{+}/H$, AT X/H = 1		0.05	0.13	0.27	0.20
JET HALF WIDTH, $W_{\frac{1}{2}}^{-}/H$, AT X/H = 1		0.29	0.11	0.23	0.24
θ/θ_{EB} AT X/H = 1		2.64	1.77	1.63	2.54
MOMENTUM RATIO, J	0.23	27.9	25.7	109.0	26.7
$\theta_{EB} = (T_M - T_{EB})/(T_M - T_J)$		0.190	0.189	0.181	0.192
MAX JET PENETRATION, Yc/H		0.50	0.50	1.0	1.0
JET HALF WIDTH $W_{\frac{1}{2}}^{+}/H$ AT X/H = 1		0.0	0.0	0.0	0.0
JET HALF WIDIH, $W_{\frac{1}{2}}^{-}/H$ AT X/H = 1		0.24	0.27	0.33	0.45
$\theta c/\theta_{EB}$ AT X/H = 1		1.43	1.37	1.41	1.75