CAVITATION DESCALING TECHNIQUES FOR GEOTHERMAL APPLICATIONS

Alagu P. Thiruvengadam
Chairman
Daedalean Associates, Inc.
Woodbine, Maryland 21797

A simple and more efficient technique for descaling hard silica scales is urgently needed in order to exploit geothermal energy resources economically. With this objective in mind, DAEDALEAN ASSOCIATES, Incorporated is engaged in a research and development program utilizing the phenomenon of cavitation for cleaning and descaling under the sponsorship of ERDA, Division of Geothermal Research. The highlights of the research carried out so far under this program is reviewed in this presentation.

Various effects of the phenomenon of cavitation erosion are presented. The intensity of cavitation erosion and its use in descaling applications are explained. The parameters governing the intensity of erosion are discussed. The overall objectives of the program are to demonstrate the engineering feasibility of utilizing cavitation and to generate engineering design data for its application in geothermal technology.

The test facility used for this research consists of flow equipment, test chamber, and associated instrumentation. The performance of cavitating nozzles have been evaluated over a range of sizes. The intensity of erosion for one specific nozzle has been measured. The cleaning rates, the quality of cleaned surface and the intensity margin available so as not to damage the pipe wall have been determined for this specific design. Further work is under progress.

DISCLAIMER

CAVITATION DESCALING TECHNIQUES FOR GEOTHERMAL APPLICATIONS

PROGRAM OBJECTIVES

- DEMONSTRATE THE FEASIBILITY OF CAVITATION DESCALING TECHNIQUES FOR GEOTHERMAL SCALES
- COLLECT DESIGN DATA ON:
  - CLEANING RATE
  - JET SPEED
  - FLOW RATE
  - NOZZLE GEOMETRY
  - SCALE THICKNESS
  - PIPE DIAMETER
  - CLEANING PROCEDURE
  - HORSEPOWER REQUIRED

ACCOMPLISHMENTS TO-DATE

- EXPERIMENTAL FACILITY WAS COMPLETED AND CALIBRATED
- FEASIBILITY OF CAVITATION DESCALING TECHNIQUE WAS ESTABLISHED
- DESIGN DATA ARE BEING COLLECTED
  - NOZZLE SIZE
  - PRESSURE
  - VELOCITY
  - SCALE THICKNESS
  - THRESHOLD INTENSITY FOR PIPE WALL
  - CLEANING RATES ON TYPICAL SCALES

INTENSITY OF CAVITATION DAMAGE

$$E_a = \triangle V \cdot S_e$$

$$P_a = \frac{\triangle V \cdot S_e}{t}$$

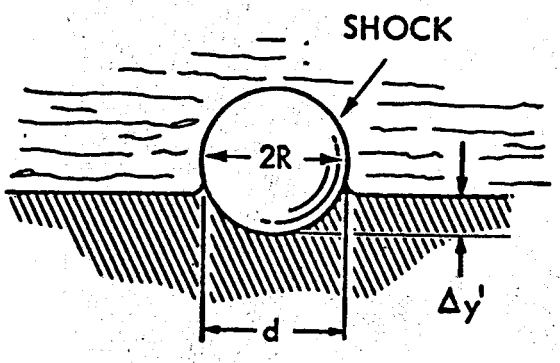
$$\text{Intensity} = \frac{\text{POWER ABSORBED}}{\text{AREA OF EROSION}}$$

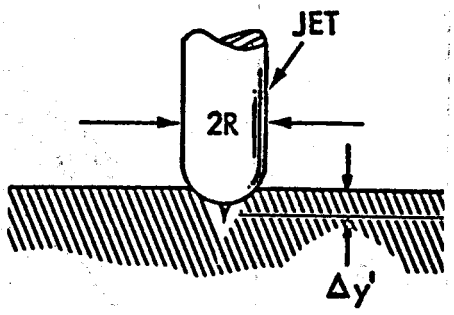
$$I = \frac{\triangle V \cdot S_e}{A_e \cdot t} = \frac{i\, S_e}{t}$$

i = AVERAGE DEPTH OF EROSION

S_e = EROSION STRENGTH OF MATERIAL

t = DURATION OF EROSION



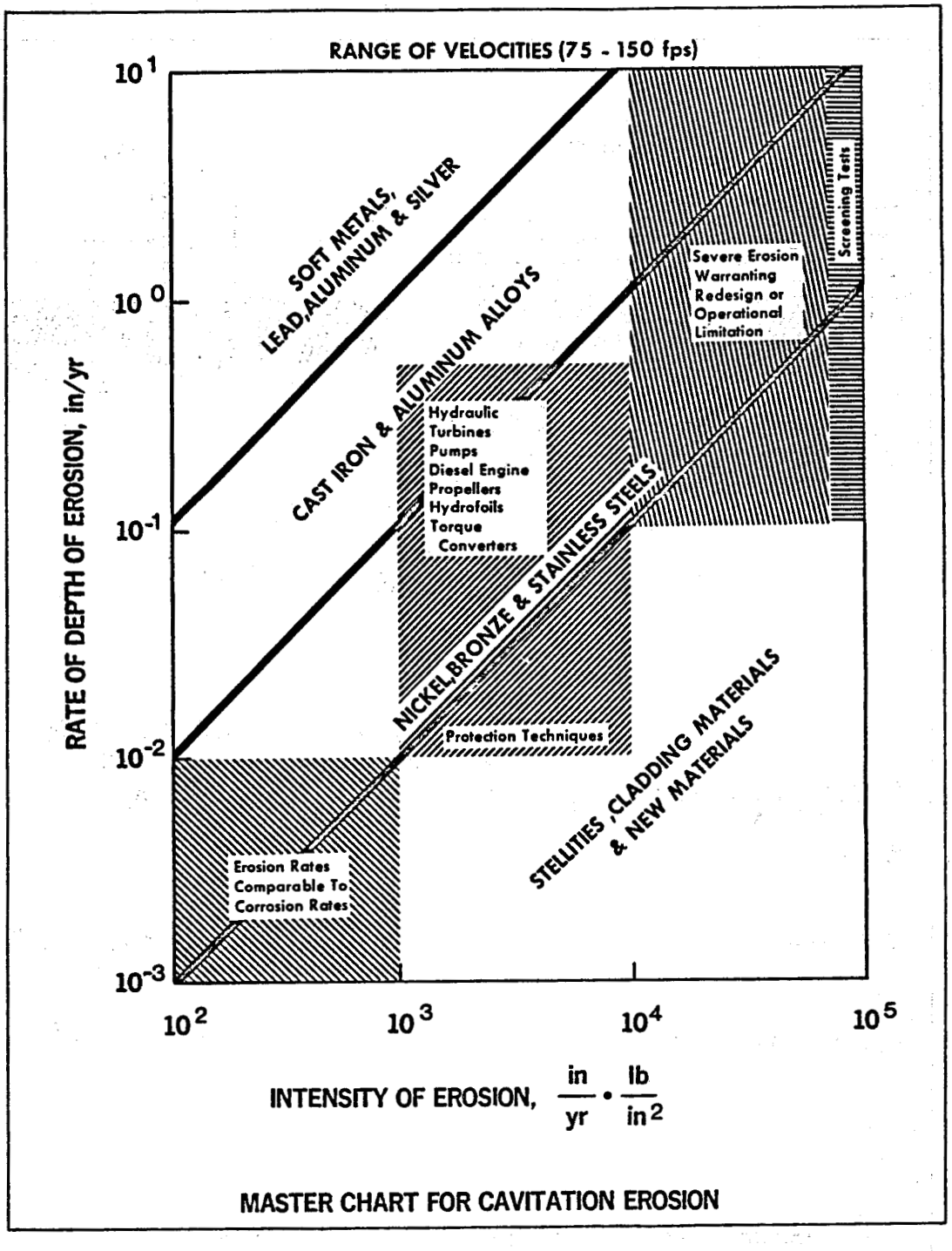


Single Impact $\quad \Delta y' \cdot S_e \propto P_i \cdot R$

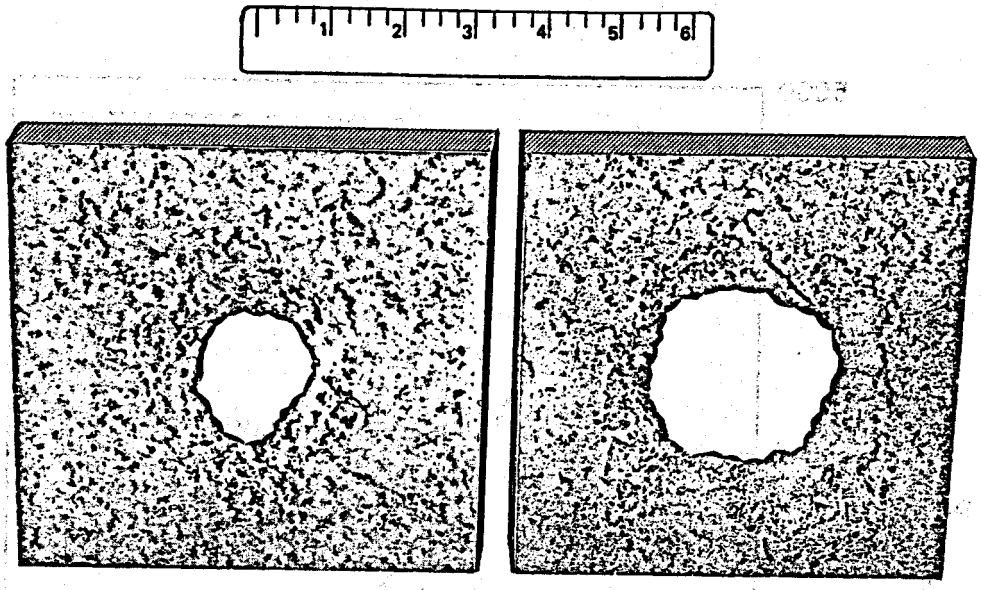
Multiple Impact $\quad \frac{\Delta y}{\Delta t} \cdot S_e \propto P_i \cdot R \cdot f$

SPHERICAL COLLAPSE	STAGNATION PRESSURE (Macrojet)	WATER-HAMMER PRESSURE (Microjet)
$P_i \propto P_o (R_o / R_c)^2$	$P_i \propto \frac{1}{2} \rho V_j^2$	$P_i \propto \rho C V_j$
For example:	$P_i \propto \frac{1}{2} \rho \cdot P_o / \rho$	$P_i \propto \rho C (P_o / \rho)^{\frac{1}{2}}$
$R_o / R_c \propto \exp (P_o / Q_o)$	$P_i \propto P_o$	$P_i \propto C(\rho P_o)^{\frac{1}{2}}$

PARAMETERS GOVERNING INDENTATION AND RATE OF EROSION

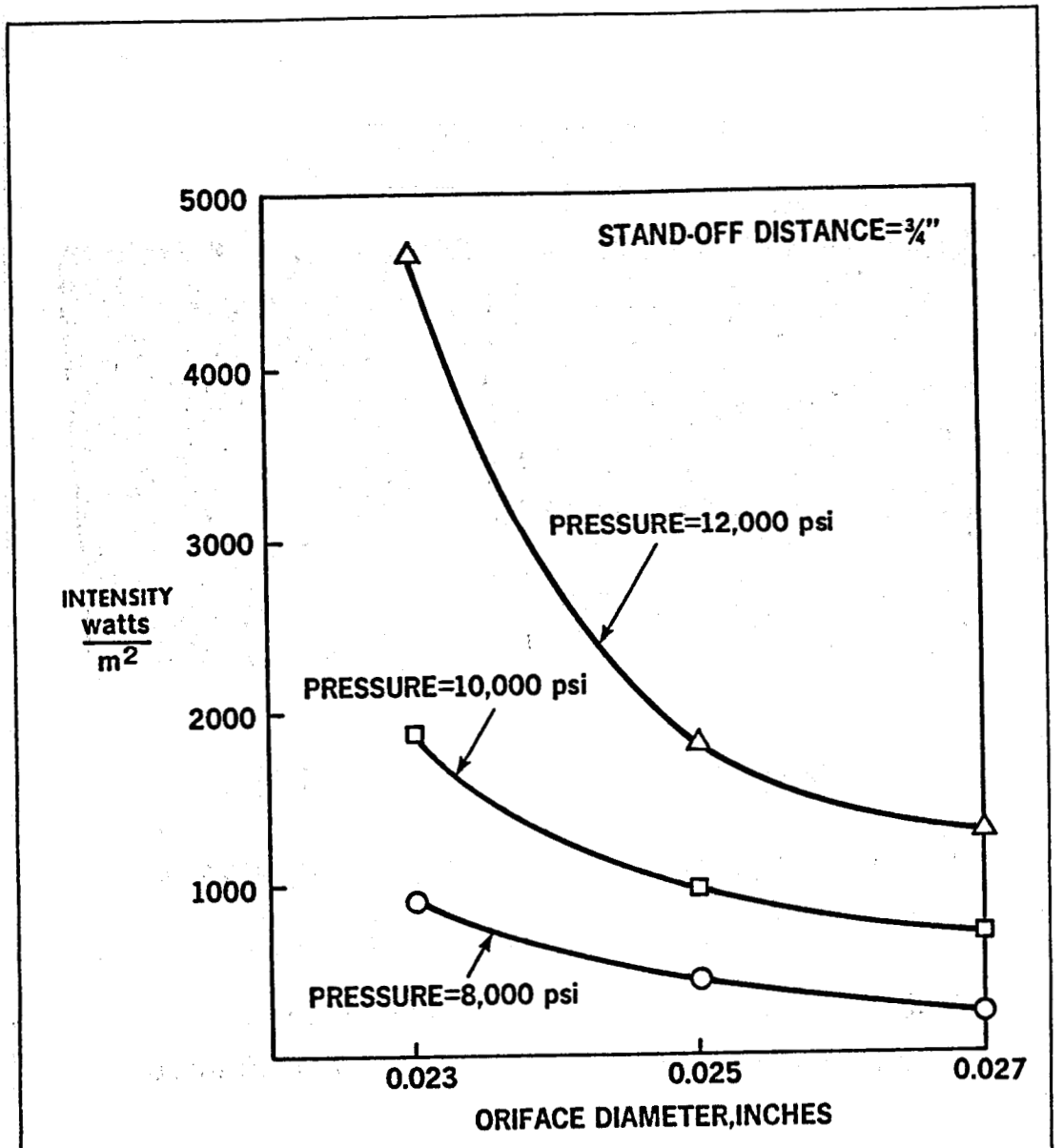


MASTER CHART FOR CAVITATION EROSION

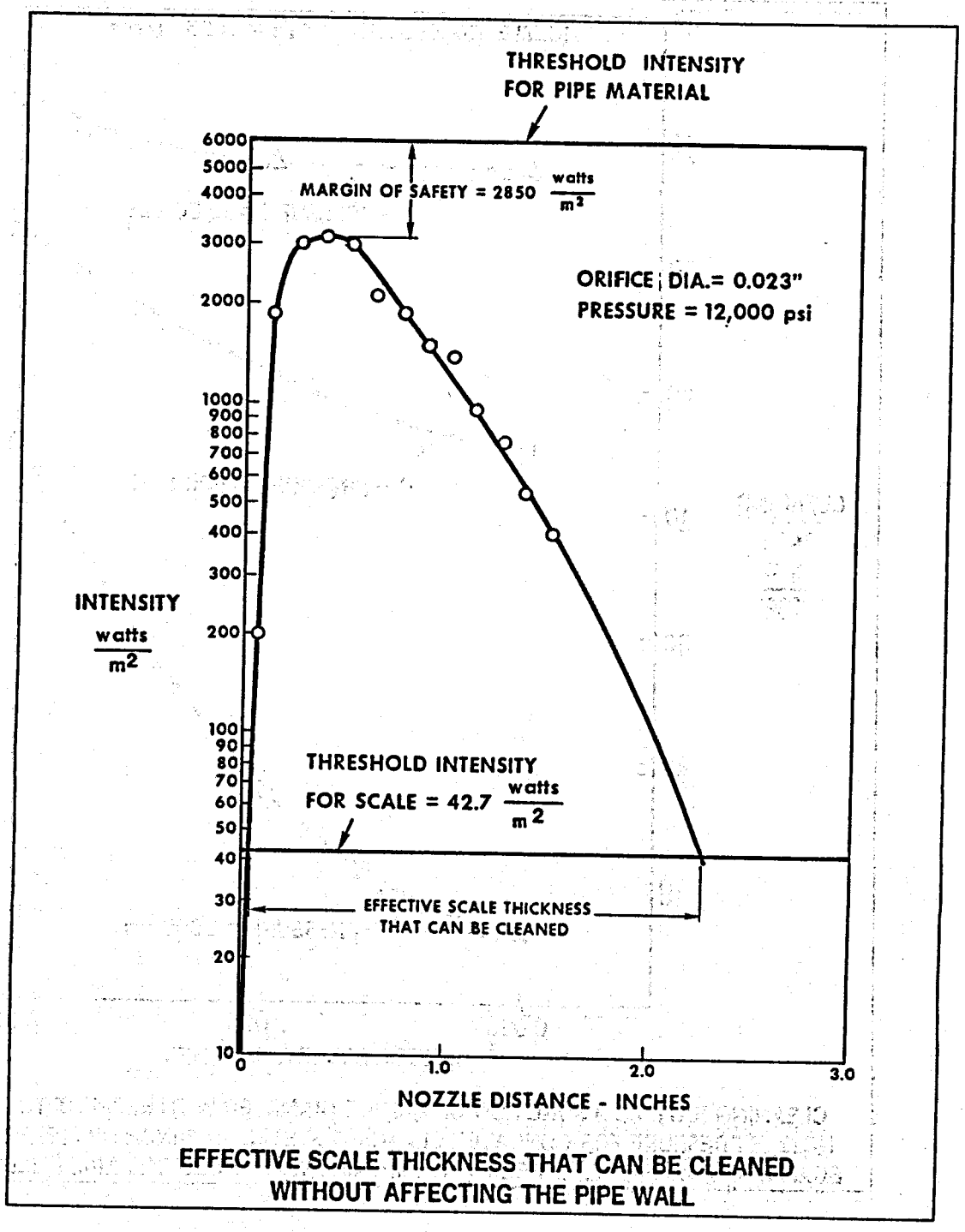


GRANITE	BASALT
COMP. STRENGTH – 35,000 psi.	COMP. STRENGTH – 40,000 psi.
DRILLING RATE – 3.0 inches/minute	DRILLING RATE – 2.5 inches/minute

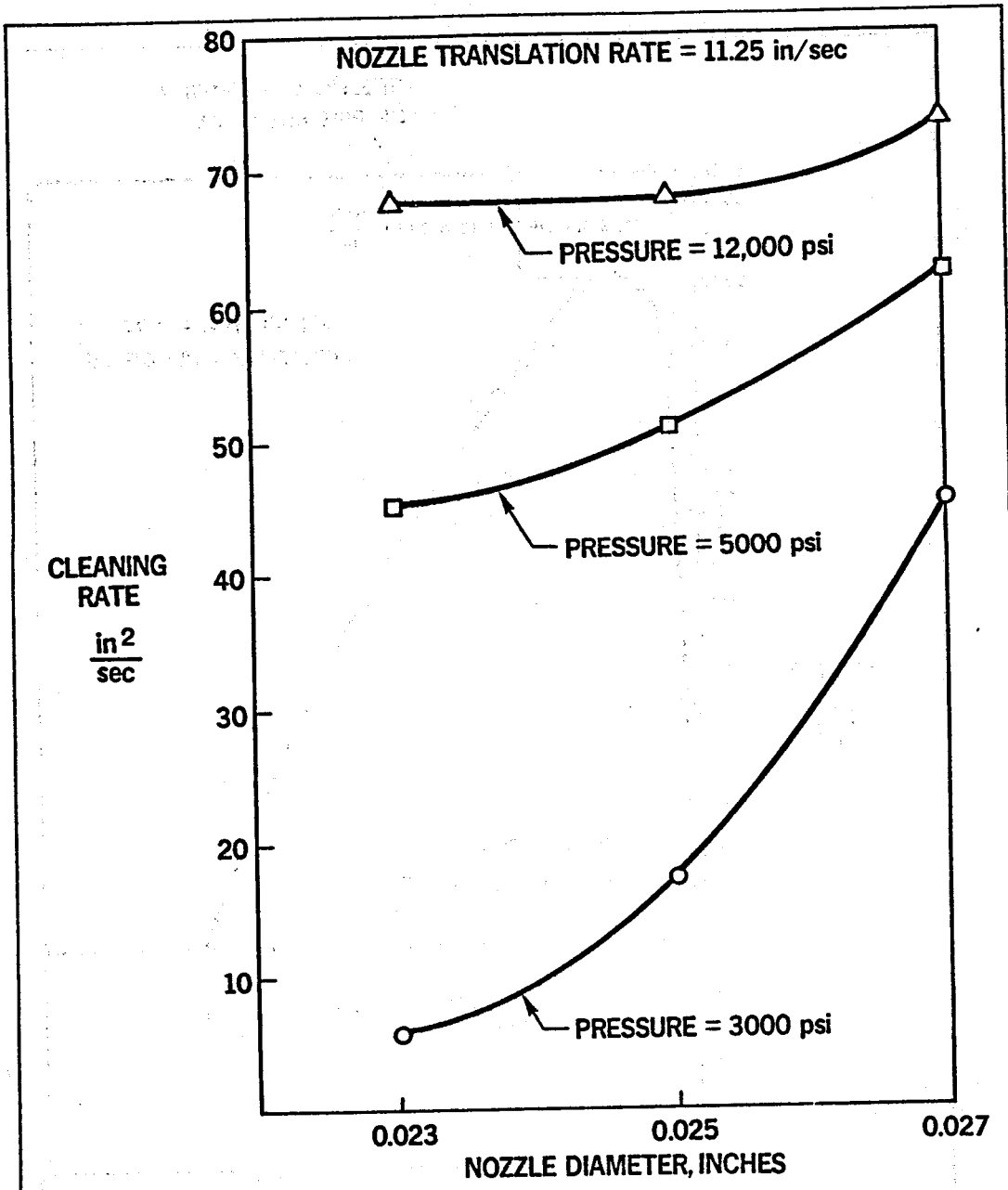
DRILLING RATES ON HARD ROCKS



INTENSITY OF CAVITATION EROSION vs. NOZZLE SIZE
AT CONSTANT PRESSURE



EFFECTIVE SCALE THICKNESS THAT CAN BE CLEANED
WITHOUT AFFECTING THE PIPE WALL



CLEANING RATE AS A FUNCTION OF ORIFICE DIAMETER WITH RESPECT TO NOZZLE PRESSURE FOR CONCAVER CLEANING SYSTEM IN 6-INCH DIAMETER SCALED PIPE AS RECEIVED FROM THE IMPERIAL VALLEY GEOTHERMAL FIELDS