AE547 Experimental Aerodynamics (2-2)3

Lecture: Monday at 9:40-11:30, Room AE 024;

Wednesday 10:40-11:30 Room AE 024

Textbook: Class notes will be used

www.ae.metu.edu.tr/~ae547

References:

•*Experimental Fluid Mechanics*, P. Bradshaw, Pergamon Press, 1970

•*Fluid Mechanics Measurements*, R.J. Goldstein (Ed.), Taylor Francis, Washington 1996. TA357.F684.

•*Handbook of Flow Visualization*, W-J Yang, 2nd edition, Taylor and Francis, 2001

•*Low-Speed Wind Tunnel Testing*, Rae, W. and Pope, A.

•*Handbook of Experimental Fluid Mechanics,* Tropea, Cameron; Yarin, Alexander L.; Foss, John F. Springer, 2007.

AE547 Experimental Aerodynamics (2-2)3

Course Outline

Experimental techniques in aerodynamics: Pressure, temperature and velocity measurement techniques.

•Steady and unsteady pressure measurements and various types of pressure probes and transducers, errors in pressure measurements.

•Measurement of temperature using thermocouples, resistance thermometers, temperature sensitive paints and liquid crystals.

• Measurement of velocity using hotwire anemometry. Calibration of single and two wire probes. Velocity measurement using Laser Doppler Velocimetry and Particle Image Velocimetry

•Other measurement techniques

AE547 Experimental Aerodynamics (2-2)3

Course Outline

1.	Introduction, Data acquisition	2 weeks
2.	Pressure measurements	2 week
3.	Temperature measurements	2 weeks
4.	Velocity measurements	
	a) Hot-wire Anemometry	2 weeks
	b) Laser Doppler Velocimetry (LDV)	2 weeks
	c) Particle Image Velocimetry (PIV)	3 weeks
5.	Other measurement techniques	1 week

AE547 Experimental Aerodynamics (2-2)3

Software

- Matlab
- LabView
- Dantec Flow Manager PIV Program

AE547 Experimental Aerodynamics (2-2)3

Grading

- HWs/Labs/Lab Reports/Projects 40%
- Attendance 10%
- 1 Midterm **(16 November 2009 @ 9:40)** 20%
  (a closed book and closed notes exam)
- Final 30%

AE547 Experimental Aerodynamics (2-2)3

Laboratory Works

Lab 1: Matlab (an introduction)
Lab 2: Oscilloscope and function generators
Lab 3: Dantec Flow Manager Program (PIV Measurements-Introduction)

AE547 Experimental Aerodynamics (2-2)3

Laboratory Works

Labs:

You will design one of the below labs. You will perform one of these labs in group of **3 persons**. You will prepare a laboratory report (lab sheet) explaining the lab, the equipment used, the experiments, calculations that will be done and you will present the lab course to the class by distributing the lab sheets that you prepared.

Lab 1: Aero Lab Open loop Wind Tunnel calibration with pitot tubes at 3 different x stations with a mesh of 2.5 cm by 2.5 cm at the test section of tunnel for 5m/s, 10m/s, 15 m/s inflow velocities. Calculations of the pressure, turbulence intensities and velocity contours.

Lab 2: Aero Lab Open loop Wind Tunnel calibration with hot wire system at 3 different x stations with a mesh of 2.5 cm by 2.5 cm at the test section of tunnel for 5m/s, 10m/s, 15 m/s inflow velocities. Calculations of the turbulence intensities and velocity contours.

AE547 Experimental Aerodynamics (2-2)3

Laboratory Works

Labs:

Lab 3: Velocity and pressure measurements using pressure tubes in the wake of SD7003 airfoil at 3 different x stations with a displacement of 1 cm at the symmetry plane of the wind tunnel for 5m/s, 10m/s, 15 m/s inflow velocities in the Aero Lab Open loop Wind Tunnel.

Lab 4: Velocity measurement using hotwire system in the wake of SD7003 airfoil at 3 different x stations with a displacement of 1 cm at the symmetry plane of the wind tunnel for 5m/s, 10m/s, 15 m/s inflow velocities in the Aero Lab Open loop Wind Tunnel.

Lab 5: Flow visualization around SD7003 airfoil using smoke for for 5m/s, 10m/s, 15 m/s inflow velocities. You should design an wake probe where the smoke will be injected to the Aero Lab Open loop Wind Tunnel.

AE547 Experimental Aerodynamics (2-2)3

Laboratory Works

Labs:

Lab 6: Flow visualization around impulsively starting circular cylinder using food dye. The visualization will be done in the 2mx80cmx80cm Water Tank of the Aero Lab.

Lab 7: Flow visualization around impulsively starting square cylinder using food dye. The visualization will be done in the 2mx80cmx80cm Water Tank of the Aero Lab.

Lab 8: Flow visualization around impulsively starting delta wing using food dye. The visualization will be done in the 2mx80cmx80cm Water Tank of the Aero Lab.

Lab 9: Pressure measurement around cylinder (or any other aerodynamic shape) by using pressure tabs on the surface of the body for different inflow velocities.

AE547 Experimental Aerodynamics (2-2)3

Laboratory Works

Labs:

For all Labs:

A first internal report is due to **11 November 2009** including literature survey, the first constructions of the setup and explaining the problems that you have encountered during the preparation of the setup. A presentation of 5 minutes will be also given in the class on 11 November.

A second internal report will be given on **23 November 2009** showing the first tests.

A **lab presentation** to the whole class will be given by your lab group on **9, 16, 23 or 30 December 2009**. (Chose a lab day that is suitable for your lab presentation, only 2 groups could present the lab in one of the days mentioned).

A final report is due to **4 January 2010**.

AE547 Experimental Aerodynamics (2-2)3

Projects

Project 1:
a) Correction of 3D drawing of Aero Lab Closed loop Wind Tunnel
b) 2D CFD results of the flowfield with a scaled wind turbine model (just the hub and the construction) at the test section. CFD simulation for different inflow velocities by using Fluent or Fastran or Star-CD commercial codes.
c) 3D CFD results with fan model

You will give
A first internal report and **presentation** of the project (showing the 3D drawings and 2D CFD results) - due to **4 November 2009**.
A second internal report will be given on **23 November 2009** and
A final report and **presentation** at the end of the semester **due to 4 January 2010**

AE547 Experimental Aerodynamics (2-2)3

Projects

Project 2a:
a) Correction of the 3D drawing of Aero Lab Open loop Wind Tunnel
b) 2D CFD results of the flowfield with the airfoil of **SD 7003** of 12cm chord at the test section. CFD simulation for inflow velocities of 10 m/s, 15 m/s by using Fluent or Fastran or Star-CD commercial codes. You should check the turbulence intensity of the model at the test section.
c) 3D CFD results of the flowfield at 10m/s
d) Calibration of wind tunnel with 5 hole probe

A first internal report and **presentation** of the project (showing the 3D drawings and 2D CFD results) - due to **4 November 2009**.
A second internal report will be given on **23 November 2009** and
A final report and **presentation** at the end of the semester **due to 4 January 2010**

AE547 Experimental Aerodynamics (2-2)3

Projects

Project 2b:

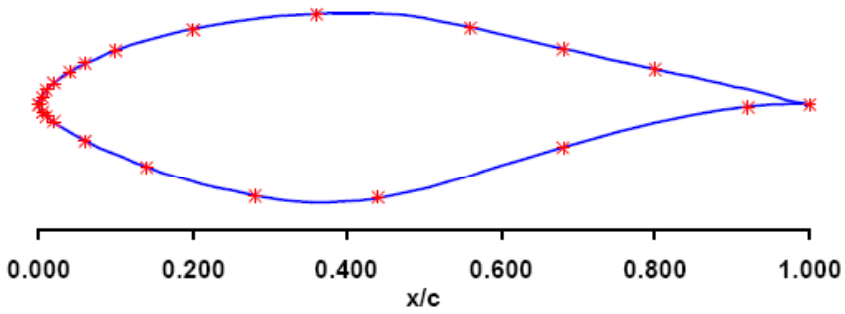
a) Correction of the 3D drawing of Aero Lab Open loop Wind Tunnel

b) 2D CFD results of the flowfield with **an airfoil shape used in wind turbines** of 12cm chord at the test section. CFD simulation for inflow velocities of 10 m/s, 15 m/s by using Fluent or Fastran or Star-CD commercial codes. You should check the turbulence intensity of the model at the test section.

c) 3D CFD results of the flowfield at 10m/s

d) Calibration of wind tunnel with 5 hole probe

- **S809 airfoil section**
- **Taps at LE and TE**
- **11 upper surface taps**
- **9 lower surface taps**



http://wind.nrel.gov/furling/schreck.pdf

AE547 Experimental Aerodynamics (2-2)3

Projects

Project 3:
a) 3D drawing of a small scale closed loop **water** tunnel
b) 2D/3D CFD results of the flowfield for inflow velocities of 5cm/s, 10cm/s, 30cm/s by using Fluent or Fastran or Star-CD commercial codes.
c) Detailed description of the components needed for the construction and construction of the small scale water tunnel

A first internal report and **presentation** of the project (showing the 3D drawings and CFD grids) - due to **4 November 2009**.
A second internal report will be given on **23 November 2009** and
A final report and **presentation** at the end of the semester **due to 4 January 2010**

AE547 Experimental Aerodynamics (2-2)3

Projects

Project 4:
a) 3D drawing of a large scale closed loop **water** tunnel
b) 2D/3D CFD results of the flowfield for inflow velocities of 0.5m/s, 1 m/s, 2 m/s by using Fluent or Fastran or Star-CD commercial codes.
c) Detailed description of the components needed for the construction with the details of manufacturing and prices.

A first internal report and **presentation** of the project (showing the 3D drawings and some CFD grids) - due to **4 November 2009**.
A second internal report will be given on **23 November 2009** and
A final report and **presentation** at the end of the semester **due to 4 January 2010**

AE547 Experimental Aerodynamics (2-2)3

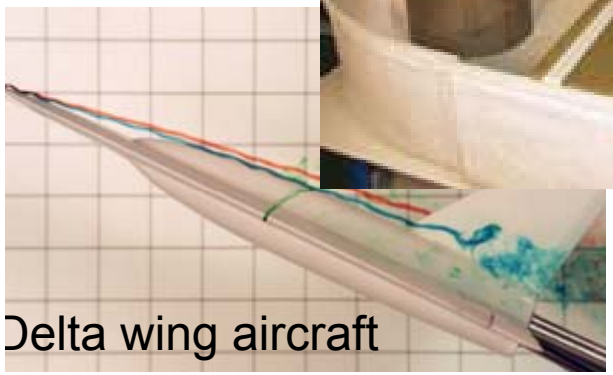
Homeworks:

•Homeworks should be performed **alone**. All the persons who have the intention to copy his/her homeworks and who have given his/her homework for copying purposes will have zero point from the homework.

•Late submissions for the homeworks, projects and lab reports will not be accepted and they will not be graded.

Attendance:

•Attendance to the Labs and project presentations are obligatory. In the case that you do not present your labs and projects with your group friends, you will not be graded for the lab presentations. Everybody in the lab and project group should present the part that he or she has been worked on.



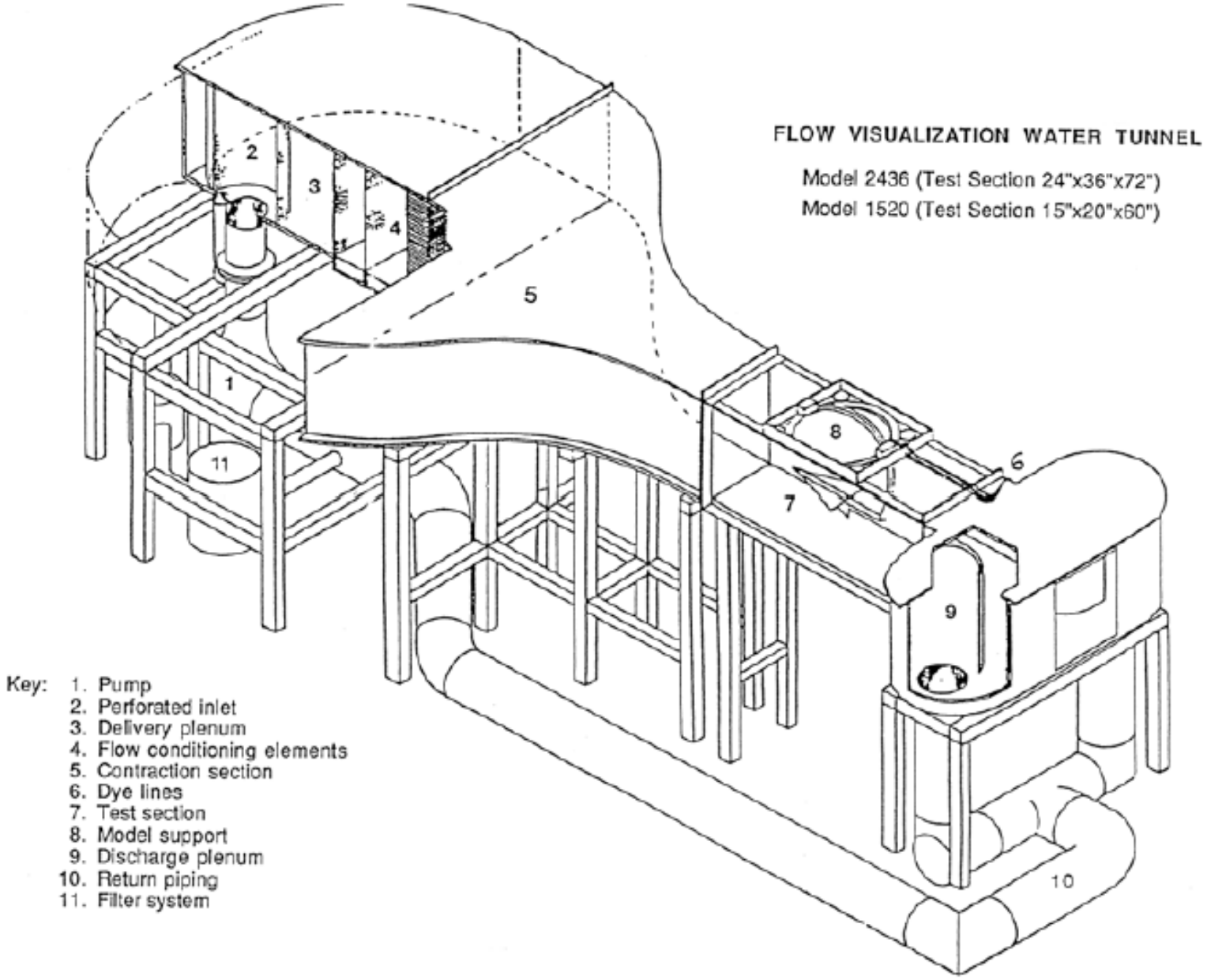
Delta wing aircraft

Length:284.48 cm
Height: 119.38 cm
Width: 116.84 cm
Flow velocity: 5 cm/s to 12 cm/s
Capacity: 397 litres of water
Centrifugal pump: 1½ hp, 115volt, 16 amper
Test Section: 7" x 10" x 18" (WxHxL)
[17.78cmx25.4cmx45.72cm]

Research Water Tunnel Model 1520

SPECIFICATIONS	
Size	30' x 15' x 6.5' (LxWxH)
Weight	7,500 lbs. w/water
Capacity	1,000 gallons =3785 litres
Test Section	15" x 20" x 60" (WxHxL) [38.1cmx50.8cmx152.4cm]
Down Stream Window	15" x 15" (WxH) [38.1cmx38.1cm]
Flow Velocity	0 to 1 ft./sec. nominal [0 to 30.48 cm/sec]
Turbulence Intensity	<1.0% RMS
Centrifugal pump	2.0hp 230VAC 3Phase 60Hz 20A
Dye System	Pressurized 6 color
Mounting Structure	Steel Frame

Research Water Tunnel Model 1520



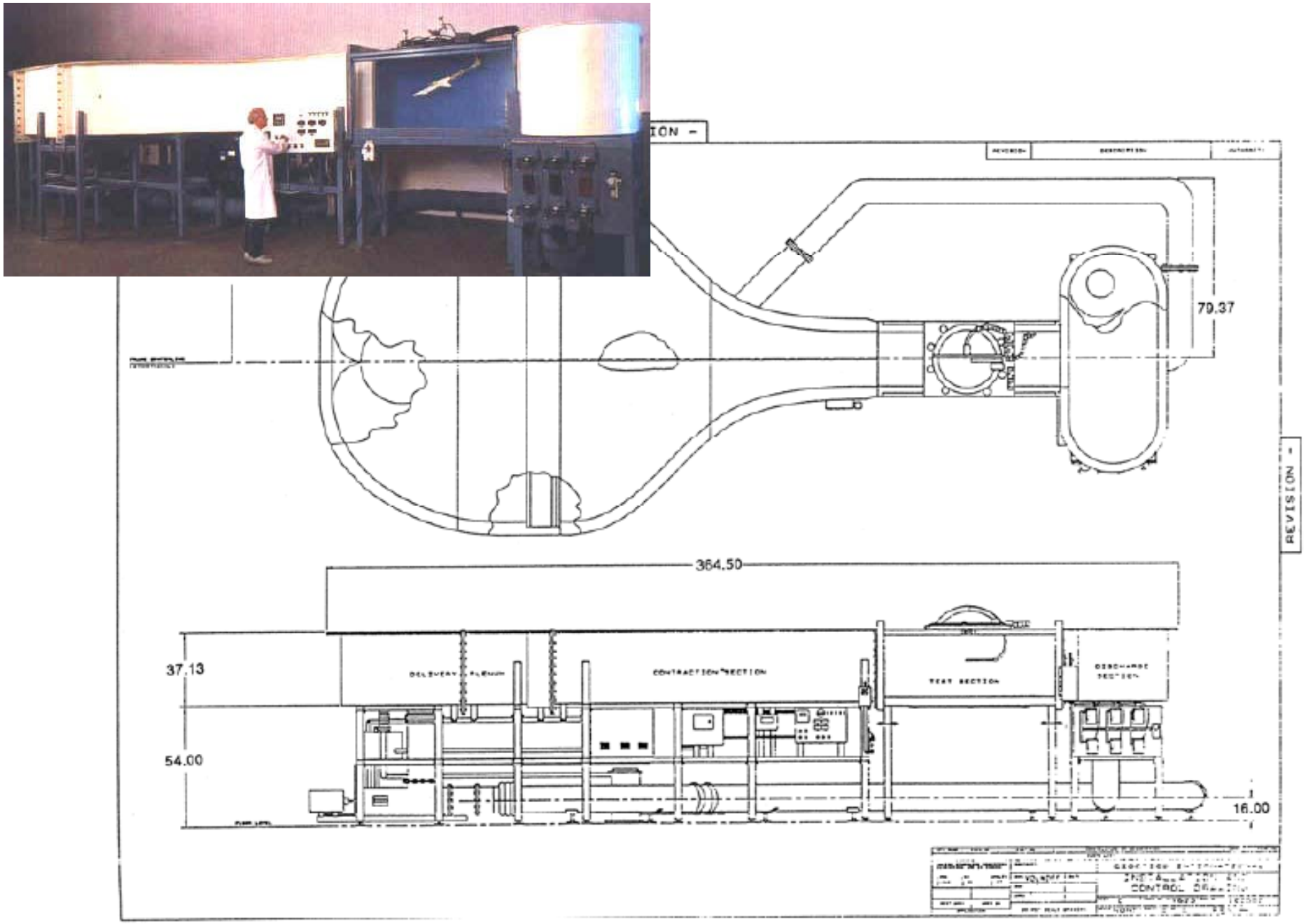


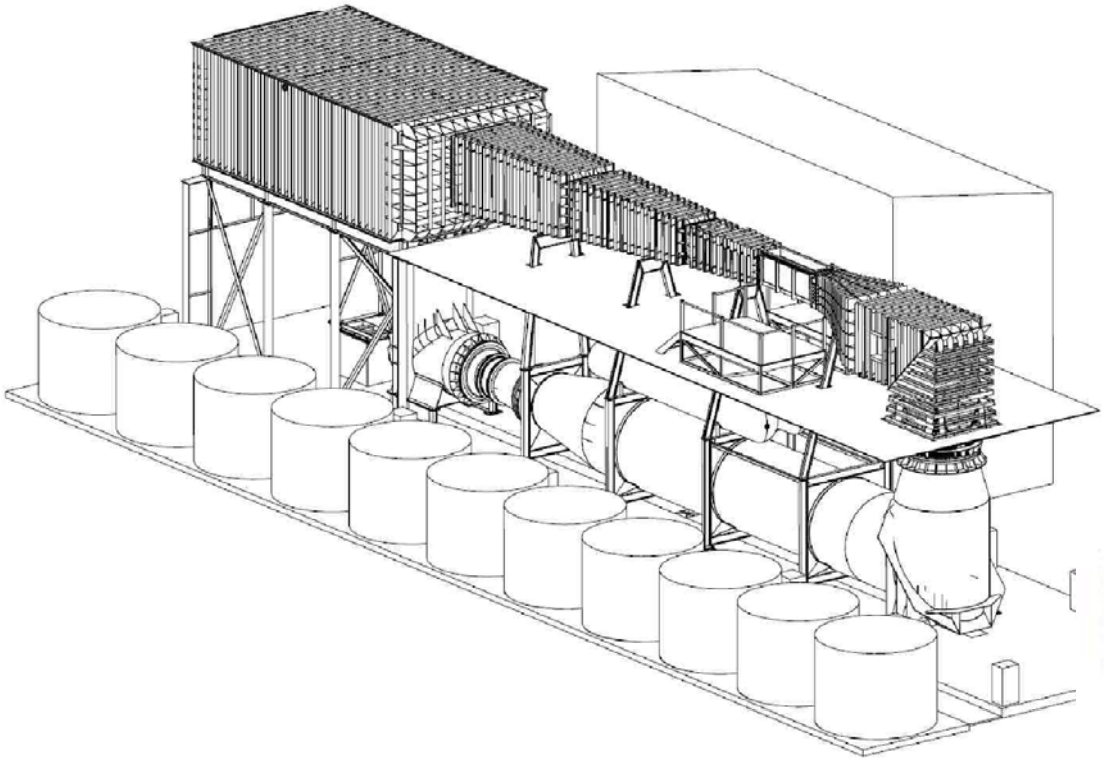
Figure 2: RHRC Model 2436 Water Tunnel

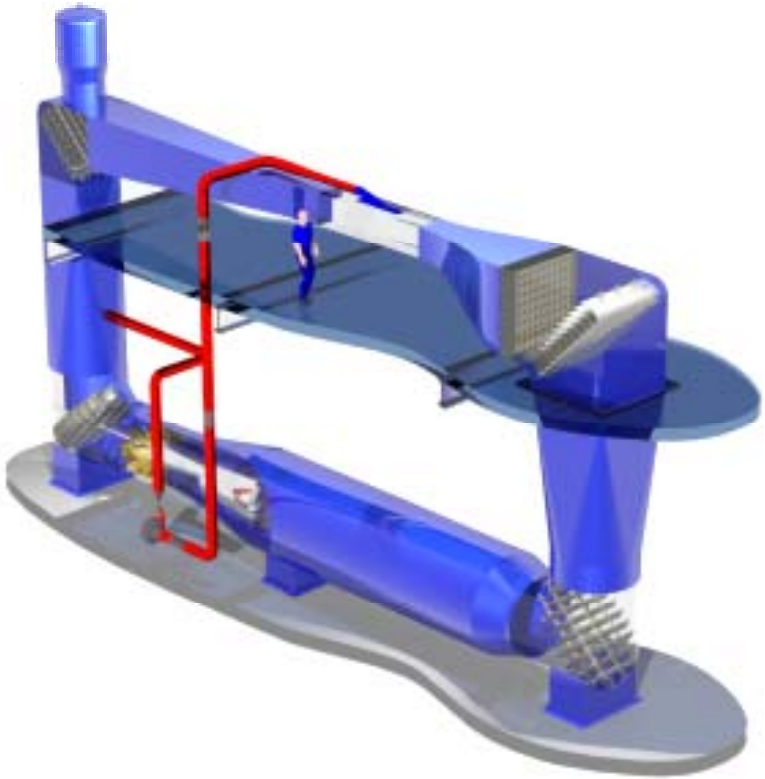
Example for a recirculation water tunnel:
http://www.amath.unc.edu/Faculty/rmm/tunnel.jpg

6" recirculating water tunnel capable of observing a wide variety of fluid phenomena including vortex streets, boundary layers, flow separation, surface waves, internal waves, jets, and turbulent mixing. Flow rates for the 6"x6" (15.24cm x 15.24 cm) visualization test section range from millimeters per second to 0.75 meters per second.

Example for a recirculation water tunnel:
http://www.amath.unc.edu/Faculty/rmm/tunnel.jpg

Other example of Water Tunnels:





Towing tank