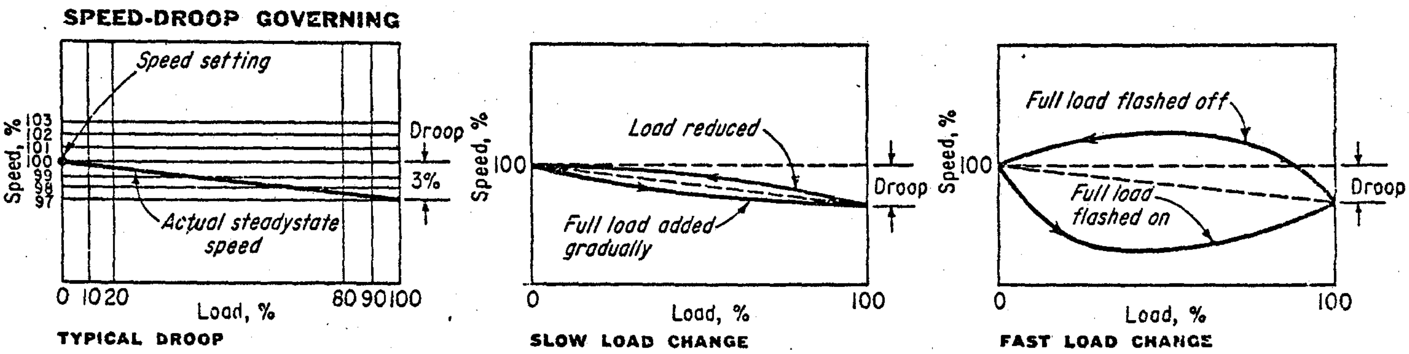
SESSION #5

GOVERNOR ADJUSTMENTS



Speed-control language

CONTROL ELEMENTS

Speed governor = primary speed-sensitive element (NEMA definition). Its output signal can be force, motion, voltage, or even a binary number. Speed sensor is synonymous here with speed governor.

Relay = electric, pneumatic, hydraulic or other amplifier that responds to the speed governor output signal and raises its energy to a more useful level.

Speed-governing system = speed governor and all auxiliary control devices needed to regulate the source of energy and thus govern speed. Typical auxiliary elements are relays, servos, and control linkages.

Prime mover = the driving engine, turbine, motor, or other rotating power-producing machine whose speed is being controlled.

Load = the driven compressor, generator, pump, gearbox, conveyor drive shaft, mixer, propeller, hoisting winch, or other power-using machine.

SPEEDS AND ADJUSTMENTS

Constant speed = one pre-set speed. True constant speed is achieved only with servo-controlled systems, but for this article constant speed means the governor is *not* adjusted by remote control while the engine is running. Suitable for generators, compressors, mixers.

Variable speed = remotely controlled speed. Operator usually can adjust speed during running from idle to any speed up to maximum. Important for locomotives, tractors, and ships.

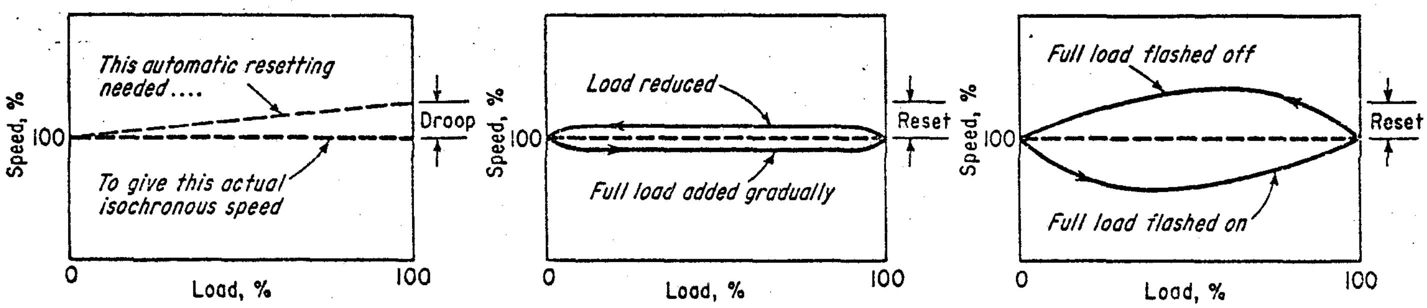
Overspeed = speed limit rather than speed control. Important where engine overspeed can destroy the machine, interfere with adjacent operations, or create a hazard. Some turbines have several overspeed governors, including centrifugal, electrical, and hydraulic. Where the governor shuts down the machine on overspeed, it is called an overspeed trip.

Two-speed = idle and normal. The idle speed setting can indicate that the start-up cycle is complete, and the normal speed setting can control normal operation.

Three-speed = idle, normal, and overspeed. One setting indicates completion of startup, one allows moderate control at or slightly below normal speed, and one prevents overspeed. Such a system can be formed entirely of speed-sensitive electric switches.

Load speed = tailshaft or driven-load speed. Load-speed control is often applied to buses and trucks to limit road speed. Also applied to the

ISOCHRONOUS GOVERNING



AUTOMATIC RESET SLOW LOAD CHANGE FAST LOAD CHANGE

output shaft of a torque converter. The load-governor signal regulates energy input to the prime mover, which usually has a separate governor to prevent excessive speed.

PERFORMANCE

Regulation = amount of speed change during or caused by application of load. The graphs above and on page 80 show the possible combinations.

Isochronous regulation holds speed constant at all loads. Speed-droop regulation entails a speed drop as load is added.

Most simple governing systems have speed droop—some as much as 1000 rpm. Also called *compensation*, speed droop is an easy and natural way to pick up load stably, because the speed change allows governor movement to actuate the engine throttle or control linkage directly.

More-elaborate governors have speed droop only during load changes with gradual automatic reset to the original speed after the load level is safely achieved.

A limited number of governors—mostly for turbine generators—have isochronous regulation, and some of these take up to 5 sec to return to the original speed after a load change.

Reset = automatic resetting of the called-for speed to compensate for droop. Makes isochronous speed control more practical. One way is to place a torque-sensing element between the engine and load with enough power output to increase the speed adjustment of the droop governor as the load is increased. This torque sensor anticipates a change in speed and acts toward correction before the speed change occurs. However, some change in speed is needed to actuate the throttle.

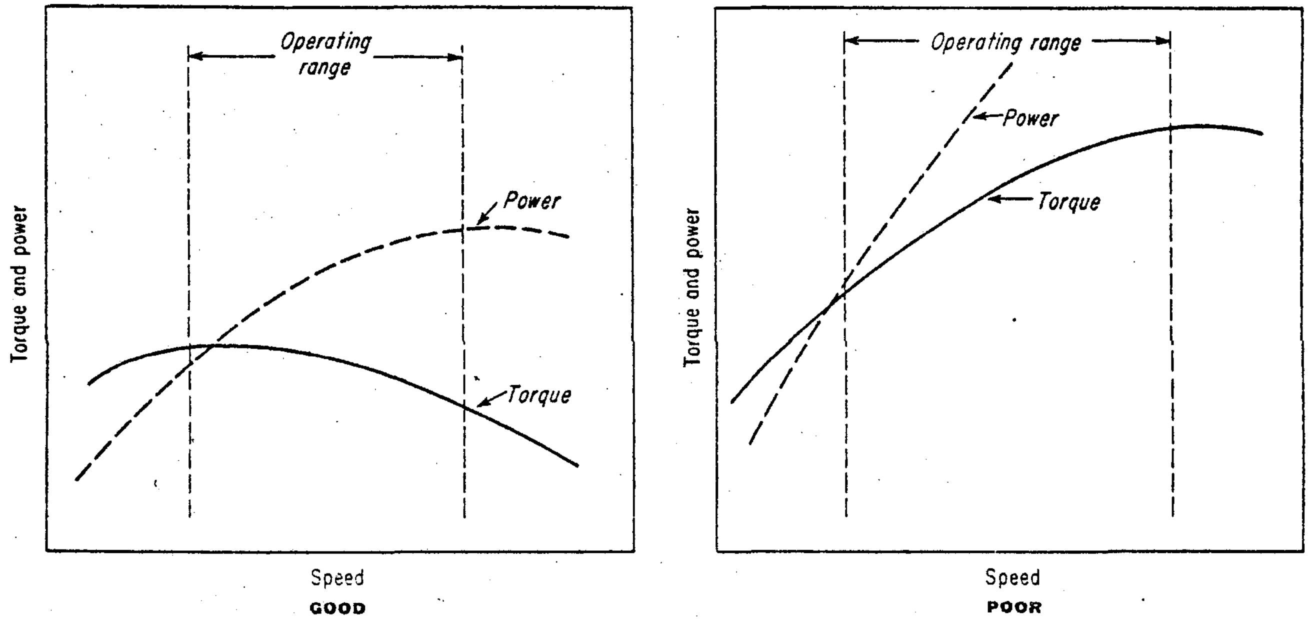
Stability = ability to maintain the set speed without undesirable speed oscillation despite load variations and other disturbances. This definition is unspecific because it hinges on the characteristics of the prime mover and the load.

Hunting = speed change without a change in load. Usually caused by worn governor parts or a design fault, such as too much end play.

Deadband = amount of speed change within which the governing system makes no measurable correction. Excessive deadband can result in hunting or instability.

Stalled work capacity = foot pounds of energy available from governor at normal speed to overcome resistance of the engine throttle and operate it through its full stroke. Stalled work capacity ought to exceed throttle work requirement by at least 50%.

Speed regulation



SELF-REGULATION OF ENGINE

Self Regulation of Drive: A prime mover will help regulate itself if output torque tends to drop as speed increases. Acceleration is lessened in proportion to loss in torque, helping stabilize the unit. All turbines exhibit the above characteristic.

In addition, wound-rotor AC induction motors exhibit the characteristic of self regulation.

FLYWHEEL EFFECT:

Transient speed and torque changes are slowed by the comibined intertia (WR^2) of the system. High inertia makes it easier for a governor to control speed inasmuch as there is more time for corrective action.

The governor adjustments used in a mechanical governor are as follows:

1. Relay restoring ration (Bell crank G5).
2. Upper floating lever (Upper in gateshaft).
3. Compensation (Temporary Droop) - Slider.
4. Dashpot needle reset time.
5. Permanent speed droop.

The action of the dashpot can be considered as consisting of two phases:

PRIMARY COMPENSATION: A function of the feedback ratio from the turbine-gate operating mechanism to the dashpot. It is generally expressed as percent temporary droop. The temporary droop may be considered as percent speed droop which would be produced by full-gate travel acting through the dashpot with its needle valve closed.

SECONDARY COMPENSATION: The recentering action of the dashpot after a disturbance. It is exprêssed as dashpot recovery time Tr and is a function of the dashpot needle.

The optimum settings will depend upon the mechanical and hydraulic charactertiscs of the unit and the stability of the interconnected electrical network which, in turn, is a function of its size.

$\delta = 2.5\ Tw/Tm$

$Tr = 5.9\ Tw$

L = length of penstock
Vo = water velocity
Ho = rated head
No = rated speed

$$Tw = \frac{\Sigma(Lvo)}{gHo}$$

WR^2 = flywheel
Po = rated power

$$TM = \frac{WR^2 NO^2}{1.6 \times 10^6 Po}$$

1. Place maximum compensation on unit to begin with.

   a. 1/8 - 1/4 needle.

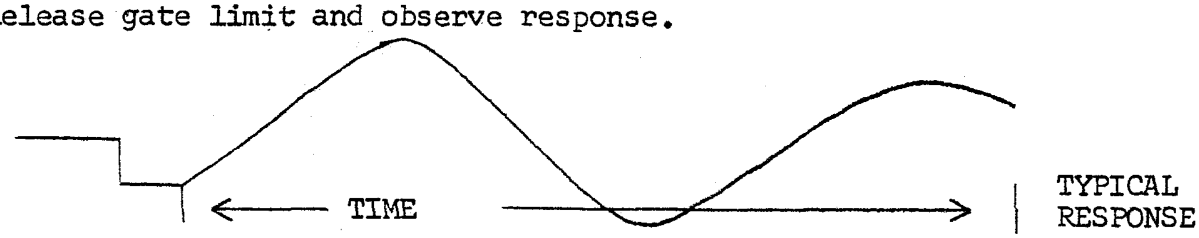
   b. RR = 10 - 15:1.

   c. Upper floating lever inner hole.

   d. Compensation 100% slider.

2. Use gate limit to reduce speed to 95%.

   a. Release gate limit and observe response.

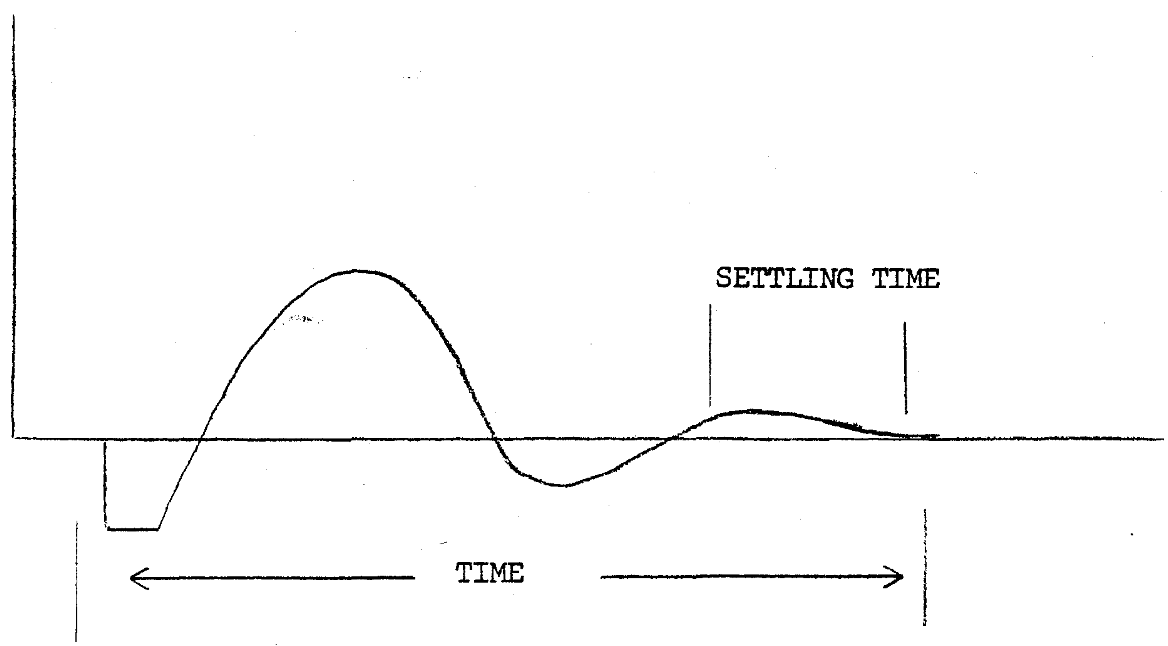
   b. 

   c. Needs more gain to reduce total time of response.

      (1) Reduce slider setting.

      (2) Reduce needle setting.

3. Results should be as follows:



a. The total time will be decreased by decreasing compensation by reducing slider.

b. The initial rate is controlled mainly by relay restoring.

c. The settling time is controlled by the dashpot needle.

The gains can be increased to the point where instability is approached.

ELECTRIC GOVERNOR

1. The derivative control reduces the natural frequencey of the oscillation.
2. The integrator reduces the settling time.
3. By adjusting the proportional gain the response can be improved.

Proportional	30%	MECHANICAL GOVERNOR EQUIVALENT
Derivative	0%	
Integral	5%	

NOTE:

MECHANICAL GOVERNOR ADJUST WITH ZERO DROOP.