Analysis and Improvement in small and medium Enterprise
A Case of Laundry/dry cleaning Facility

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Copyright Statement

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Abstract

Small and Medium scale enterprise plays a key role in the prosperity and stability of under developing countries such as Pakistan, an import based economy because of which it is very expensive and sometimes beyond fiscal limits of such enterprises to update or keep up with the latest technology and machinery used by developed countries. Hence relying on second hand, imported and outdared technology and equipment is the only way for such industries to survive, while at the same time consuming more energy and resources, a toll on both economy and resources of the country. Laundry/dry cleaning industry is one of such enterprises, which is also the focus of this thesis, the analysis of industry has identified different aspects that can employ improvements based upon the results from the analytical study and simulation done on the software package. Human resource management, ergonomics, quality control, standardization and energy conservation are the focal concerns of this study. Implementing results of the research will optimizing the current setup of the industry while keeping in mind constrains and limitations encountered due to financial and energy shortage.

Key Words: *Laundry/dry cleaning, fiscal limits, simulation software, human resource management, ergonomics, quality control, standardization, energy conservation*

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Abbreviations

ACGIH, American Conference of Governmental Industrial Hygienists
ANSI, American National Standards Institute
ASSE, American Society of Safety Engineers
BHP, break horse power
BOD, biochemical oxygen demand
COD, chemical oxygen demand
cSt, centistoke, kinematic viscosity unit
CNS, central nervous system
GL, Giga liters
GAC, granular-activated carbon
GPD, gallon per day
EPA, Environmental Protection Agency
EC50, Effective Concentration – Half Maximum
GPM, gallon per minute
GDP, Gross Domestic Product
HMIS, Hazardous Materials Identification System
IPH, industrial process heat
IARC, International Agency for Research on Cancer
IDLH, immediately dangerous to life or health
kWh, kilowatt hour
LD50, Lethal Dose – Single dose killing 50% of test subject (animal) population
LC50, Lethal Concentration – Single exposure killing 50% of test subject (animal) population
ML, million liters
MSDS, material safety data sheet
ME, Medium Enterprise
MTT, mineral turpentine oil
MSHA, Mine Safety and Health Administration
MDGs, Millennium Development Goals
MNC, Multi-National Cooperation
NIOSH, The National Institute for Occupational Safety and Health
n.e.c, not elsewhere classified
NESHAP, National Emission Standard Hazardous Air Pollutants
NTU, nephlometric turbidity unit
NFPA, National Fire Protection Association
OSHA, Occupational Safety & Health Administration
ppm, parts per million
PFA, Process flow analysis
PCE, Perchloroethylene
PEQS, Punjab Environmental Quality Standards
PLC, Programmable Logic Controller
PKR, Pakistani Rupees
PSIC, Pakistan Standard Industrial Classification
Q, volumetric flow rate
RCC, roller compacted concrete
RO, reverse osmosis
SBP, State Bank of Pakistan
SG, specific gravity
SMEs, Small and Medium Enterprises
SDGs, Sustainable Development Goals
SBA, small business administration
SM, Small Enterprise
TSS, total suspended solid
TDS, total dissolved solid
TLV, threshold limit value
TAED, tetra acetyl ethylene diamine
TH, total hardness
TWA, Time Weighted Average
UF, ultrafiltration
UNDP, United Nation Development Programme
VFD, variable frequency drive

CHAPTER 1: INTRODUCTION

The research work in this dissertation is carried out in concern to economic and energy shortage that has enveloped the small and medium scale enterprises that not only contribute significantly in the economy of Pakistan but are also responsible for the consuming substantial resources. Present research only covers a single enterprise that is a part of a service proving sector of Pakistan, a Laundry and Dry cleaning facility that provides services related to textile products washing and cleaning. These services utilizes significant resources in the form of electricity, natural gas and ground water.

1.1 Small and Medium Enterprises

Small and Medium Enterprises (SMEs) have been known to have contributed to country's economic growth and employment. In the industrial development of a country the importance of the SME sector cannot be overemphasized also they are critical for the economic and social development of emerging economics of the world. They play a major role in:

- Creating jobs
- Generating income for low income people
- Foster economic growth
- Economic stability
- Innovations
- Social stability and integration
- Improve Living Standards
- Contribute to the development of a dynamic private sector

1.2 Background

According to The World Bank Small and Medium Enterprises (SMEs) play a vital role in most economies, particularly in developing countries. Existing SMEs adds up to 60% of total employment and up to 40% of national income (GDP) in emerging economies. In reality these percentage contributions are significantly higher when informal/unregistered SMEs are included. Bringing informal SMEs into the formal sector can have substantial benefits for the SME (for instance, better government services and access to credit) and to the overall economy (higher tax revenues and better regulation). As per the statistical estimates, 600 million jobs will be required in the next fifteen years to engage the growing global workforce, mainly in Asia and Sub-Saharan Africa. In incipient markets, formal jobs are mostly created by SMEs, which also create 4 out of 5 new positions[1].

Poverty, being the far most pressing issues for developing and emerging economies can be easily tackled by bringing reforms that can improve present conditions of SMEs and create an environment where micro and small enterprises can take emerge easily. In the Millennium Development Goals (MDGs) and presently Sustainable Development Goals (SDGs) given by United Nation Development Programme (UNDP), poverty has remain the first priority. The economies that have emerged in the last few decades have continuously supported SMEs financially and technologically so that they can contribute to the economy of their countries in the long run. Present Multinational Corporations (MNCs) known as "The Big Giant" were not as big when they started, it was the SMEs that later on transformed into present MNCs, some of them have even annual budget that exceed the budget of small countries.

1.3 Small and Medium Enterprises in Pakistan

The definition of SME described by the State Bank of Pakistan (SBP) is in terms of the number of employees and annual sales turnover. Also defined the limit of finances given to then in the form of business Loans. See table 1-1 [2].

Table 1-1 : SME as per State Bank of Pakistan

Enterprise Category		**No. of Employees[1]**	**Annual Income (PKR)**	**Business Loans (PRs)**
Small Enterprise (SE)		50 Max	150 Million (Max)	25 Million (Max)
Medium (ME)	**Trading Establishment**	50 ≥ 100	150 ≥ 800 Million	25 ≥ 200 Million (Max)
	Manufacturing/ services	50 ≥ 250	150 ≥ 800 Million	25 ≥ 200 Million (Max)

Both conditions must be met for SME i.e. No. of employees and annual turnover.

SMEs constitute nearly 90% of all the enterprises in Pakistan, employ 80% of the non-agricultural labor force, SMEs share in the annual GDP is 40%, approximately. However, unlike large enterprises in the formal sector, a SME is constrained by financial and other resources. This inherent characteristic, makes it imperative that there should be a mechanism through which it may get support in different functions of business including[3]:

- Technical upgradation
- Marketing
- Financial
- HR training & development

[1] Including contract employees

The table 1-2 shows the SME clusters which are developed by SMEDA for the purpose of revitalizing SME sectors, under the finical sector Restructuring Program of Government of Pakistan.

Table 1-2 : Small and Medium Enterprise Sectors[3]

Sr. no.	SME Sectors	Clusters
1	Ginning Technology Up-Gradation	Textile / Apparel
2	Program Lending For Power Looms	
3	Computer Aided Design Centre (Common Facility Centre-Sialkot)	
4	Designing Institute for Garments (Peshawar)	
5	Accessories Sector Study	
6	Development of Handloom Cluster	
7	Establishment of Cool-Chain Agriculture Export Processing Zone	Horticulture / Fruits and Vegetables
8	Fruit Processing Facility (NWFP in Collaboration with EPB)	
9	Assistance to Set Up Horticulture Export Board	
10	Revitalization of Sunflo-Cit-Russ for Citrus Cluster Development.	
11	Apple Treatment Plant in Baluchistan (Co-Ordination with EPB)	
12	Program Lending Boat/Engine Modification, Gwadar District	
13	Establishment Of Shrimp Farms	
14	Fish Processing Facility In Gwadar (Feasibility) Granite & Marble	
15	Export Warehouse Marble (Azakhel NWFP)	
16	Establishment of Model Quarry and Training Institute Marble	
17	Joint Ventures and Technology Transfer Arrangements (NWFP)	
18	Five New Gem Mines To Be Operationalized (NWFP)	Gems
19	Lapidaries Program Lending (NWFP)	
20	Glass & Ceramics	
21	Ceramics Kiln Up-Gradation: Common Facility Centre, Gujrat	
22	Sanitary Ware & Pottery Sector Kiln Up-Gradation	
23	Bangles Kiln Up-Gradation (Hyderabad)	
24	Agri-Mall – One Stop Shop for Agriculture Inputs	Agriculture
25	Support Services for Agricultural Credit (SSAC)	
	Establishment of 3 Private Sector Warehousing & Trade Promotion Facilities in Afghanistan	

1.4 The Case Study

The case study in this research work also comes under the umbrella of small and medium enterprise (SME), related to the service providing sector that deals with cleaning/refurnishing garment and textile product. With respect to the classification of industry, Pakistan Standard Industrial Classification (PSIC) place it in Sector-S (Other Service Activities), Division – 96, Group 960 – other personal service activities, Class – 9601,Washing and (dry-) cleaning of textile and fur products, see table 1-3 [4].

While North American Industry Classification System (NAICS) defines this sector by its size (as small Business classification) and place it in sector 81 – Other Services, Subsector

812 Personal and laundry Services, NAICS Code 812320 – Dry Cleaning and Laundry Services (except Coin-Operated).Contrary to PSIC, the small business size standard classification system as per Small Business Administration (SBA) of United States has defined different standards for different business with different annual returns or number of employees, instead of having a single rule for every business, see table 4-1, chapter 4.

Table 1-3 : Pakistan Standard Industrial Classification – Section S (Total A – U)

Section S Other Service Activities			
Division	**Group**	**Class**	**Description**
94			**Activities of membership organizations**
	941		**Activities of business, employers and professional membership organizations**
		9411	Activities of business and employers membership organizations
		9412	Activities of professional membership organizations
	942		**Activities of trade unions**
		9420	Activities of trade unions
	949		**Activities of other membership organizations**
		9491	Activities of religious organizations
		9492	Activities of political organizations
		9499	Activities of other membership organizations n.e.c.
95			**Repair of computers and personal and household goods**
	951		**Repair of computers and communication equipment**
		9511	Repair of computers and peripheral equipment
		9512	Repair of communication equipment
	952		**Repair of personal and household goods**
		9521	Repair of consumer electronics
		9522	Repair of household appliances and home and garden equipment
		9523	Repair of footwear and leather goods
		9524	Repair of furniture and home furnishings
		9529	Repair of other personal and household goods
96			**Other personal service activities**
	960		**Other personal service activities**
		9601	Washing and (dry-) cleaning of textile and fur products
		9602	Hairdressing and other beauty treatment
		9603	Funeral and related activities
		9609	Other personal service activities n.e.c. (not elsewhere classified)

1.4.1 Introduction to the facility

The facility is a professional service provider, each service comprises of several activities and processes, although many activities and processes are similar but at the same time use of different equipment's for specific products makes it unique and different from other services. These services can be categorized with respect to the cleaning method and type of product to be cleaned.

1.4.2 Cleaning Methods

Cleaning Methods are of three types two of which are water based while the third one is chemical based.

- Washing
- Steam laundry
- Dry Cleaning

1.4.2.1 Washing

As from the name itself, it is the most common method mankind has ever known for the cleaning purpose. Plane water with some additives live detergent or soap are used to remove the dirt and stains off the clothes, after words clothes are rinsed i.e. wash with water without using any additives, to remove the excessive detergent socked by the clothes. Now to remove water spinners are used which removes more than 85% water from the wet clothes. To completely remove the water contents, clothes are hanged on the roof top under the sunlight. Along with the sunlight intensity another factor; adequate air flow is also vital since air is the medium which carries the water moisture from the clothes.

1.4.2.2 Steam laundry

The increase in human population results into requirement of new resources. To overcome such a demanding situation synthetic garments i.e. unnaturally created, have been produced over the period of time. Textile industry also developed synthetic fabrics and even composites of natural and synthetic fabrics, their different proportions results into significant change in the nature and properties of the cloths.

Among these properties also involves some of the very hard and rugged type which required high temperature cleaning. Steam laundry is one of the methods in which temperatures above ambient conditions can be achieved easily. In this method steam is used to increase the temperature of the water used for cleaning. Separate and special equipment is used in this laundry. Condense Steam which gives hot water is directly introduces in the washing machine, detergent is also added in the machine. Rinsing is also done by hot water in a machine, remaining drying of clothes is done by the same method as that of a simple washing process discussed before.

1.4.2.3 Dry Cleaning

As from the name ‘dry’ one can suggest without getting wet but that is not all to this cleaning method. Of course without getting wet with respect to water is true but clothes do get wet in a chemical. In this cleaning instead of water Mineral Turpentine Oil and other dry cleaning oils/chemicals are employed. Special and expensive clothes like pent coat and ladies embroidery dresses which are delicate and can easily get their colors ruined once come in

contact with water are dry cleaned. The machines used for dry cleaning are sophisticated, they only work with chemicals and temperature controlling is also required. Dry cleaning chemical is much expensive so extracting back and recycling is also done by the machines. Special purpose drying machine are used to dry the chemical containing clothes.

1.4.3 Types of Garment and Fabric

In our daily life we use many products other than wearables which are made of fabric and without them living become incomplete and colorless. Yet alone wearables are of so many types that their classification becomes necessary along with their cleaning methods. Their frequency of use is such that one cannot deny their general addiction.

From cushioned chairs, seats, sofa sets to blankets, bed sheets, curtains and carpet, all these things are products of fabric. Since their rate of use is such that they need periodic cleaning and if not cleaned, will lost their finish and durability and as a result their refurnishing or replacement become inevitable which is much costly as compare with its cleaning.

Many wearables and products have same cleaning method but still different cleaning methods cannot be applied to same product or fabric neither different fabric or clothes be mixed together to be cleaned at the same time. Their separation according to type is very important and necessary otherwise they may get permanent damage or unserviceable. Their classification according to their type is given in the table 1-1.

1.4.4 Service Cycle

The Service cycle basically describe the processes through which a ‘product to be serviced’ must go through. In a cleaning method there are different stags (processes) which must be performed step by step to complete a service cycle. A general service cycle is described in figure 1.1. In the later chapter a more comprehensive version of service cycle along with its process flow and different stages of a process are shown.

Table 1-4: Types of Product[1]

Gents Items		
Boy Coat	Jacket Leather	Sherwani Tilla / Zari Work
Bushirt Suit	Jersey	Sweater
Cap	Open Shirt	Tie
Chadar	Dress pant	Track Suit
Coat	Qameez Shalwar	Trousers
Dhussa (Gents Shawl)	Karandi / Karhie Work	Waist Coat
Jacket	Sherwani / Gown	Waist Coat Suiting
Ladies Items		
Blouse	Dupatta Simple Silky	Shawl (Pashmina)
Burkha Gown	Gharara Suit / Lehnga	Shirt Salwar (3p & 4p)
Caip / Stole	Long Coat	Shirt Salwar Silky
Wedding dress	Saree Banarsi Silk	Shirt Salwar Simple
Coat	Saree Simple	Shirt Salwar Cotton
Dupatta Mukesh & Zari	Scarf	Shirt Salwar Velvet
Dupatta Simple	Shawl	Shirt Salwar Zari
Miscellaneous Items		
Blanket Single / Double Layer	Cushion With Foam	Bed Sheet Printed Silky Single
Blanket Double / Double Layer	Carpet Woolen	Bed Spread (Double)
Car Seat Cover	Carpet Hand Made	Bed Spread (Single)
Cushion Cover (Per Piece)	Towel Small	Pillow Cover Cotton / Silk
Curtain Velvet Lining (Per Panel)	Towel Large	Quilt Cover Cotton / Silk
Curtain With Lining (Per Panel)	Vest / Bundi	Quilt Polyester (Single)
Curtain Without Lining(Per Panel)	Bed Sheet Cotton Single	Quilt Polyester (Double)
Carpet Synthetic	Bed Sheet Double	Sofa Set, Five / Seven Seater

[1] Data in Table 1-4 is a courtesy of Amar Pak Laundry and Dry cleaners (some Urdu to English Words)

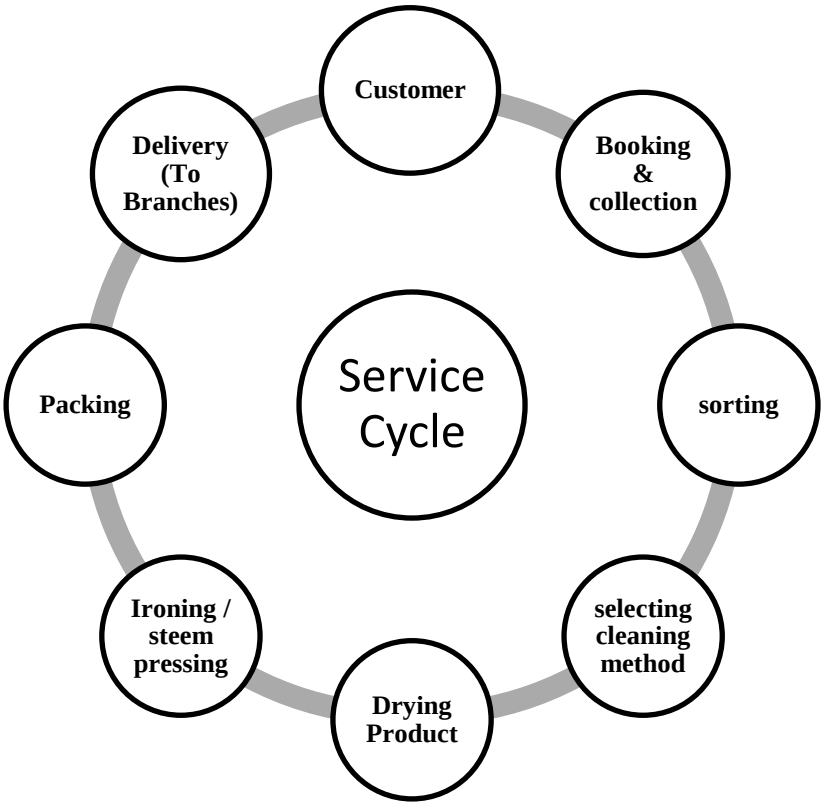


Figure 1.1 : Service Cycle of a Product

1.5 Scope

This dissertation is intended to analyze and recommend concrete measure for the present facility related to a sub-branch of the industrial service providing section of Pakistan. This facility related to laundry/dry cleaning comprises of number of engineering and management aspects, from service cycle to process efficiency and from human resource to quality control. Analysis and improvement in these aspects will significantly affect the cost-effectiveness and resource management.

Within the service sector, laundry/dry cleaning industry has a reasonable contribution in the total economy of the country. Implementing results of the research will optimizing the current setup of the industry while keeping in mind constrains and limitations encountered due to financial and energy shortage. The application of this research is for all small and medium size commercial laundry and dry cleaning facilities.

1.6 Methodology

The facility under consideration is scrutinize at different levels of interest and analysis. It was necessary to identify and specify the factors/aspects and conditions/limitations, which were later on became the focus of the research. Literature review shows the different aspects concerning to this service sector that have been researched upon in different parts of the world but this study focuses on entirely different aspects specific to Pakistan. To better understand and evaluate the present system, a simulation software package is utilized. Results deduced identifies some simple factors which can be worked upon to bring reform at ground level without capitalizing a large fiscal amount in importing modern and expensive technology from developed countries.

CHAPTER 2: LITERATURE REVIEW

An important source of information is literature review. The research work done by other authors related to a particular field helps in understanding the case or the problem in a more descriptive and systematic way while saves a lot of time which otherwise would be lost in understanding and searching from the beginning and may be identical to another research. It is like doing the same thing again which kills the purpose of research that is why literature review guide us to the next and novel parts of the research which has yet to be uncovered. Moreover, literature review provides information that may not be native to the case that is under research. International information on a particular case especially the research work carried in other countries (Developed ones) can be easily collect, analyzed and utilized as per requirement by means of literature reviews. Only after doing so one can come up with an original and creative research work that will have credibility in the national and international conferences.

2.1 Different aspects of Review

In the present dissertation different aspects were identified at the initial level of analysis (discussed in later chapter). Research done by other authors on different aspects of the case under consideration, were identified along with their applications while their relevancy toward present research is another aspect of the study. A portion of literature reviewed aspects and related researches are discussed in this chapter, related to Environmental Contamination, Eco-Toxicity Analysis, Recycling, Social Perspective, Handling of Detergents, Renewable Energy Sources, Ergonomics and Organizational Work Climate.

2.2 Water Pollution

The 1.4×10^9 km^3 of earth (about 70% of surface area) is being contained by water and about 0.5% is naturally available for sustaining all life on earth, while remaining comprises of salt water, icecaps and in the form of soil moisture. Roughly 30% of surface area on which humans live is supplied with only 0.5% of earth's water which is utilize by agriculture, industries and households of the entire world[5]. Taking it as for granted, contaminating it and depleting its resources for centuries has finally made the world realize that their very existence revolved around the fresh water supply.

One of the tenacious traits of laundry industry is environment contamination. Water being the major resource, used as a solvent in cleaning the clothes. Moreover, there is no other solvent that can be used as a replacement for water hence a large amount of ground water (a natural resource) is used and dirty water containing chemical such as detergents and softeners

along with the dirt/lint removed from the clothes is released into the main stream of the water sewage that later on joins up with rivers and other water bodies.

2.2.1 Recycling Laundry Waste Water

The industrial laundry service providers are one of the largest users of fresh water and they also produce a large quantities of wastewater. In many countries, dry-cleaning is a partially used method for cleaning garments, mostly use water based laundry and because of scarce water resources, industries pay a lot for the amount of water consumed.

A study of a European based industrial Laundry (Turin, Italy) revealed that the water needs of the industry was covered by well water. Before being used, well water is softened by ion exchange resins and then stored in a tank. Studies shows that an average of 15 liters of water is utilized per 1 kg of garments, with average 400m^3 discharge of water waste per day, also called laundry gray water as a common name. Waste water from industrial laundries have a high microbiological load and levels of pollutants (suspended solids, fats, oils, etc.) and numerous chemicals and surfactants from dirty clothes and washing operations respectively. All these pollutants are difficult to remove from effluent water by conventional processes, hence causes an environmental pollution problem. Finding solution for efficient treatment of wastewater with a cost-effective technology is a top priority. Consequently, a novel trend in the laundry industry is to reduce freshwater consumption, which can be accomplished by closing the water cycle, meaning reusing / recycling of waste water [6].

Table 2-1: Characteristic of Laundry Waste Water[1]

	Parameters	**Units**	**Laundry Waste Water (Average Value)**
1	Temperature	^oC	33
2	pH value	---	7.7
3	Turbidity	NTU	92
4	Conductivity	µS/cm	2249
5	Chemical Oxygen Demand, COD	mg/l	317
6	Total Solids, TS	g/l	15
7	Total Nitrogen, TN	g/l	5.5
8	Total Phosphorous, TP	g/l	16.8

In a study related to membrane bioreactor (MBR), a full-scale submerged aerobic membrane bioreactor (9 m^3) was used to treat / recycle laundry wastewater and examined for duration of 9.6 months (288 days). Characteristics of waste water from that laundry are given in table 2-1[7].

[1] Bioreactor volume 9 m^3, average daily flow 30m^3/day, hydraulic retention time HRT=0.3 days, organic loading rate OLR=600-2260 mg COD/l per day, solid retention time SRT=6500 Days.
Flat sheet Kubota membrane type FS-75. Flux 0.5 m^3/m^2/day, transmembrane pressure TMP=1 to 2 kPa

After recycling the turbidity and total solids (TS) were reduced by 99%, the chemical oxygen demand (COD) removal efficiencies were between 70% and 99%. The levels of COD removed by the membrane were significantly more than the levels of biodegraded COD. This enabled bioreactor to sustain COD levels that were below 100 mg/l, even during days of low waste water biodegradation due to bioreactor sludge. Table 2-2[7], represent data related to different waste water treatment system.

Table 2-2 : Different systems for treating laundry waste water

Treatment System with reference	**Study scale L=Lab F=Full P=pilot**	**Q, Waste water (m^3/day)**	**pH Value**		**COD (mg/l)**		**Electrical conductivity (µS/cm)**		**Turbidity (NTU)**		**TSS (mg/l)**	
			In	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**
Granular Activated Carbon (GAC)[6]	L	360	7.2	7.4	602	140	1342	1275	110	1.1	166	4
Ultrafiltration (UF)[6]	L	360	7.2	7.3	602	81	1342	1127	110	0.8	166	2.5
Sedimentation and filtration[8]	F	1.8-1.9	8.02	7.71	310	310			10.27	2.40	380	40
Biological treatment Followed by Chemical separation[9]	F	100	8.5-9.8	7.0	295	94					71	14
Advanced oxidative process UV/O_3/Fe^{2+} 150mg/L. [10]	L	48-58	9.56-7.83		3343	946	415	1526	1904-786	956-675		
Flocculation with $Al_2(SO_4)_3.18H_2O$ and adsorption on GAC [11]	L		9.6	6.8	208	20					35	5
Ultrafiltration[11]	L		9.6	8.3	280	130					35	18
Ultrafiltration + Reverse Osmosis[11]	L		9.6	8	280	3					35	8
Electrocoagulation and electroflotation[12]	F	36	9.56-7.24	8.15-7.24	1090-785	45.6-32.4	1904-786	856-675	583-471	12.3-8.26		
Electrocoagulation and electroflotation[13]	L		7.5		226a	90						
Nanofiltration[14]	F		7-9		1350	95						
Submerged aerated membrane bioreactor 14 L/m^2 h. 125 m^3 [15]	F	200	10-11	8.2-8.6	700	60	2000	2000				
Submerged aerated membrane bioreactor 15 L/m^2 h. 126 m^3 [16]	F	200			1120	67						
Submerged membrane bioreactor[17]	P	10			1200	60	1000-3000	1000-3000				
membrane bioreactor[7]	F	30	7.7	7.5	317	80	2249	2240	92	0.4	15 g/l	0.2 g/l

An economic based evaluation of the MBR system showed that the installation of the membrane and construction of the MBR accounted for 36% of the total cost, while construction of the other remaining tanks accounted for 22% of the total cost and total capital cost was 72,500 € with a savings of 1.13 € per 1 m^3 of water. The payback period for the system is approximately 6 years. Only 5 % of the total cost of the MBR system represent the energy and maintenance costs [7]. Present foreign exchange rate till august 2017, an average rate is 114.2749 PKR per EUR, while at the time of construction of the plant in 2008, average rate was 107.9215 PKR per EUR. Hence the plant total cost was 7.82 million PKR and present cost turns out to be 8.28 million PKR[18]. While cost of import, transportation and import duty is yet to be calculated.

2.2.2 Use of recycled water for domestic laundry

Normally, 15–20% of household water is utilized in laundry purposes. However, water consumption for laundry in different households may vary considerably due to the variety of types of washing machine, their number, laundry water temperatures, load sizes, etc. The laundry practices adopted in different regions of the world are summarized in the table 2-3 [19]. The type of washing machine is one of the main factor affecting the annual water consumption in laundry. Front loaders commonly consume less than half as much water per wash as top loaders, which is why European households use significantly less water compare to Asian and North American households. However, they consume additional electricity and energy to heat-up water. Overall, more than 9.9 kiloliters (kl) of fresh water can be saved per household per year worldwide, if recycled water is used instead of fresh water[19].

Table 2-3: Average Yearly Regional Laundry Practices of a Household

Region	Type of Washing Machine[1]	Load per wash (kg)	Washing temperature (ºC)	Water consumption per wash (L)	Number of wash per year	Water used for laundry (kL)
West Europe	>98% front	3-4[a]	40	60	165	9.9
East Europe	>98% front	3-4[a]	40	60	173	10.4
Turkey	>90% front	-	60	60	211	12.7
North America	>98% top	3-4	15-48	144	289	41.6
Australia	>68% top	-	20-40	106	260	27.6
China	>90% top	1.3-2	Cold water	99	100	9.9
South Korea	>90% top	-	Cold water	140	208	29.1
Japan	>97% top	~3	Cold water	120	520	62.4

[1] Front = front loader machine; Top = top loader machine; [a] shows 75% machine capacity.

During the preliminary stages of planning, qualitative feasibility analysis regarding new end uses of recycled water has pinpointed different aspects that influence implementation of recycled water schemes (see table 2-4)[19].

Table 2-4 : Qualitative feasibility analysis of recycled water schemes

Qualitative Feasibility Analysis	Domestic Laundry
Strengths	Washing clothes, a year round activity, Significant fresh water consumption
Opportunities	Expand the dual pipe water supply system. Considerable freshwater saving and reduced effluent discharge. Current recycled water (microfiltration or advanced treatments) can be safely used. Higher possibility of the public acceptance.
Weaknesses	Close human contact. Need of extra taps to connect the dual pipe system to laundry. Lack of safety data and relevant guidelines. Lack of comprehensive quantitative assessment.
Threats	Distrust the quality of water and concerns about health issues. Water hardness forming scum. Public concerns on physical appearances live color, odor, potential damage to clothes (e.g., iron, staining garments) and washing machines, and increased cost due to water recycling plants.

2.2.3 People's perspective towards Recycled Water

Many countries have reached to the limit where their water supplies are insufficient to sustain present and future water needs. At the same time increased population, along with the uncertainty of water supply conditions due to climate change, amounts to a mushrooming water shortage has radically increased concerns towards resolving water demands. These countries have been faced with public resistance towards adoption of recycled water projects. To resolve this matter engineers and social scientists have to work together. Engineers can provide the best, safest and most energy efficient solutions to insure continuous water supplies, on the other hand social scientists can enable better understanding of the reasons for public resistance towards acceptance of water from recycling water plants and suggest ways in which public policy makers may be able to increase acceptance of alternative water sources and find solutions which are most acceptable for the public[20].

Use of recycled water for household laundry can be regarded as a promising strategy to lessen the current water supply demand. An Australian based research revealed that household water consumption is the second largest user of water about 20% domestic water is consumed in the laundry practices. Significant freshwater savings could be achieved if recycled water is used for washing clothes. There were over 580 different recycled water projects across Australia in 2013, which were mostly associated with non-potable uses (irrigation, industry,

residential uses and environmental flows). Above all, the households' use of recycled water continued to increase, with a 6% growth from 3106 ML in 2009-2010 to 3283 ML in 2010-2011. Still, the amount of treated effluent being reused (351 GL in 2010-11) in Australia is still low compared with the total discharged wastewater and there is considerable inconsistency in water management across local, state and territory governments. Numerous dual pipe systems have been installed in new residential areas, it was anticipated that 40,000 new homes and businesses in Melbourne will use an additional amount of recycled water, which would bring the water recycling rate from 22.8% (2009-10) to 26.1% by 2015. The results of the study constructed regression relationships between predicting variables and the public acceptance on recycled water use in laundry[21]. These variables which significantly contributing to the acceptance of this new end use of recycled water were:

1. Optimistic attitude on receiving recycled water
2. Optimistic opinion regarding "recycled water is an alternative to drinking water"
3. Increased confidence by reading or hearing from other customers successful examples
4. Increased confidence by installing a small unit to improve the water quality.

The hindrance to use of recycle water are: potential odor and high cost when using recycled water for household laundry[21].

2.3 Toxicity of Laundry Detergent

Detergents are widely used chemicals group worldwide. Large quantities of detergents and their components enter the environment. Since Ceriodaphnia dubia is used in toxicity testing of wastewater treatment plant effluent water in the United States, one of the research concerns with Toxicity of Laundry Detergent to a Cladoceran and their Contribution to Detergent Toxicity. The toxicity of 39 laundry detergent components including surfactants, enzymes, builders, fabric brighteners, fillers, and coloring agents to the cladoceran was determined. Analysis revealed that mixtures of the components interacted antagonistically, additively and synergistically. On a molarity basis the most toxic group of compounds was the surfactants followed by the brighteners. The main contributors to the toxicity of detergents were the sodium silicate solution and the surfactants with the remainder of the components contributing very little to detergent toxicity. The potential for acute aquatic toxic effects due to the release of secondary or tertiary sewage effluents containing the breakdown products of laundry detergents may frequently be low[22].

In another study the acute toxicity to Daphnia magna was determined for 26 detergents and five softener, Swedish products. Some of their constituents are highly toxic to aquatic

organisms. In Western Europe, approximately 4250 kilotons detergent products and 1190 kilotons softener products are used annually. The detergent consumption in Sweden in more than 50 kilotons annually. A typical Swedish detergent is made of a surfactant, a builder (zeolite-A), its builder additive (polycarboxylate) and a bleaching agent (percarbonate). Other minor components are enzymes (proteases), bleaching agent activators (TAED) and perfumes. Softeners are primarily made of water and surfactants. The vast majority of detergent products reach the environment as components of domestic and municipal wastewater after consumer use of these products. Detoxification tests, with and without inoculum of sewage organisms, showed that after 16 days all tested products were acute detoxified and addition of sewage organisms considerably increased the rate of detoxification. Toxicity and the biotic detoxification rate was correlated with the concentration of surfactants used in the products (more surfactants increased toxicity and a slower rate of detoxification). These results emphasize the importance of biological purification of domestic waste water and recommends formulation of less toxic and more easily degradable surfactants[23].

2.4 Handling of Detergents

Occupational health studies have associated respiratory and skin problems with detergents, hence information on handling detergents is very important for the proper and safe use of detergents. Carrying out cleaning tasks includes the use of chemical detergents which are usually considered to provide cleaner and safer homes. Women being the foremost users of household detergents are more prone to health risks. Handling of detergent include storage, use, and precautionary measures, affect women's exposure to chemical detergents and their health. In this study of determining detergent handling strategies, women's potential exposure was investigated by an ergonomics methodology combining in-depth interviews and observations. Results indicated that the majority of women in the studied sample did not take notice of the potential hazards of storing household detergents under or on top of the sink, in close proximity to food and shampoo, and in non-original containers without proper labels[24].

There are several differences between workplace and household environment, it include constraints related to choice of product, storage and length of exposure. For instance, in Lebanon the built environment is characterized by confined spaces, which affected women's habits and strategies for handling and storing chemical detergents. While laundry cleaners have general larger storage space along with relatively more relaxation on the choice of the cleaning agent, laundry service providers frequently use what's available in their workplace[24].

2.5 Organizational Climate and Employees' Performance Relationship

Climate that is built upon the interaction of employees of different status, posts and departments significantly influence the performance of the department and organization. It also provide bases to many physical and psychological phenomena of the workforces. Bullying is one of the phenomenon, usually caused by the organizational climate. Studies related to the relationship between organizational climates, workplace bullying and workers' health substantiates the causes which leads to negative effects on performance and health of employees. With respect to present dissertation, the facility under study provides professional services which are performed by workers using different machines, hence worker's performance directly links to the quality of services. The organizations must keep check and balance on those risk factors that might have negative effects on the employees' health particularly bullying at workplace which can be one of the major factors[25].

Table 2-5 : Causes and Effects of Workplace Bulling

Sr. no.	Causes of Workplace Bulling	Description
1	Organizational Climate	how work is organized, the culture or climate of the organization, and the nature of the leadership within the organization
2	Leadership	unfair and abusive management practices might constitute occurrence of bullying at work place
3	Job Description	high levels of role ambiguity and conflict, a perception of contradictory expectations, goals and demands along with unclear structures of command
4	Organizational Dynamics	Organizational change can bear stressful workplace environment leading to bulling and workers' health issues
5	Social Norms and Culture	social perceptions or real time treatment that individuals receive from others at place of work
6	Working Conditions	Negative working conditions can lead towards occurrence of bullying, due to lack of communication, cognizant miscommunication, which in itself affects information flow and cooperation.
7	Time Pressures	With regards to time pressure, face uncertainty because of role ambiguities and unclear responsibilities.
Effects Upon Employees' Health		
	Effects	**Description**
1	Health Disorder	occupational stress may contributes to clinical depression, anxiety, post-traumatic stress disorders, stroke, heart attack, death and medical disorders
2	Smoking/Drug Abuse (Addiction)	To release stress some turns to smoking and the Abuse of various other drugs. Nicotine in cigarettes has pharmacological affects that moderates stress level
3	Hours of Sleeping	health problems if not solved or mitigated, may arouse the development chronic effects like excessive sleep problems

With respect to workplace bullying, many adverse behaviors have been identified, that includes physical assaults, offensive comments, unfair removal of responsibilities and work tasks, spreading rumors and social isolation. Various UK surveys indicated that bullying in

about 3 out of 4 cases is a hierarchical process that is directed by someone in a supervisory or managerial position at an outranked or under-ranked personal. The table 2-3 represent causes and effects of bulling at workplace[25].

2.6 Renewable energy as an alternative for industrial thermal supply

Inherently solar energy is a renewable resource that has the potential for supplying the industrial thermal requirement in a more environmental friendly manner. Thus contributing to the enactment of industrial ecology. A substantial portion of the industrial energy demand is direct thermal energy, known as industrial process heat (IPH). Industries which require thermal demands ranging from 120 to 250 ^{o}C are food and beverages (drying, evaporation, pasteurization and sterilization), wood treatment (compressed and drying), paper (blanching, boiling and drying), chemicals distillation, metal and plastic treatment and automotive industry (painting). Small-sized parabolic-trough collectors (PTCs) are suitable renewable energy generating technology for covering the thermal energy demands ranging from 120 to 250 ^{o}C temperature[26].

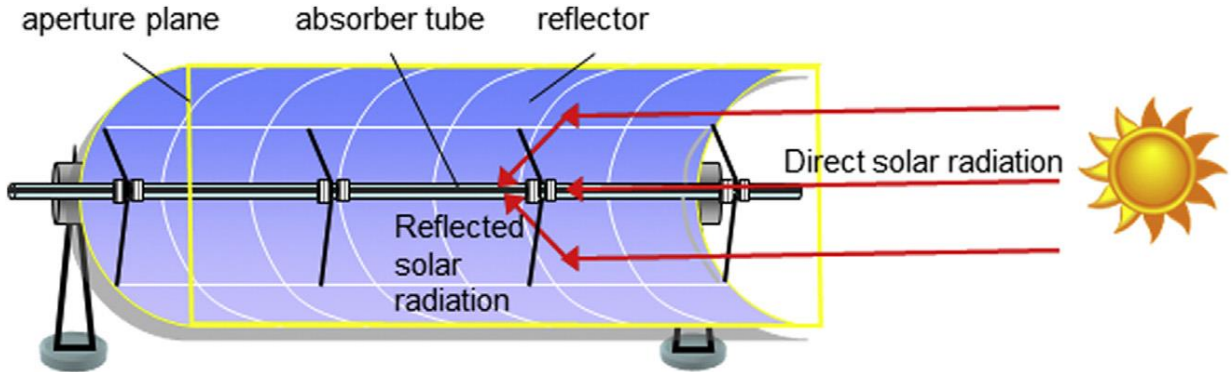


Figure 2.1: Parabolic-Trough Collectors (PTC) [26]

PTCs are solar technology containing concentrating reflectors that focus the direct solar radiation received at the aperture plane onto a focal line (see Figure 2.1[26]), while thermal transfer fluid that flows through an absorber tube, fitted at the focal line, absorbs concentrated solar energy from the tube surface and raises the fluid temperature. The collector is provided with an uniaxial solar tracking that ensures falling of solar radiations parallel to its axis[26]. The research was based upon numerical simulation. The thermal performance of different parabolic-trough solar collector designs were compared by keeping same operational and ambient conditions. Simulations showed that the collector with only flat glass aperture cover has the highest thermal losses. However, with both flat glass aperture and tube covers thermal losses were lower than the one with a glass tube cover only. At the same time optical-geometric efficiency is inferior and overall efficiency is slightly low. Additionally, reflector with thermal insulation on the back was not recommended[26].

2.7 Business Competence Indicators for Small and Medium Enterprises

This study interviewed 15 respondents who were regarded as experts in the Small and Medium Enterprises issue. There were five categories of experts (academicians, policy makers, supporting government agencies, chambers of commerce, and industries) that were taken into consideration and for each category, three experts were interviewed. Interviews were conducted for a duration of 60 to 90 minutes. Table 2-6, shows the results from the interviews[27].

Table 2-6 : Competence Indicators

Competence	**Business Competence**	**Themes – International business competence indicator**
Capability to meet the standard	Achieve the set objective for which the business was driven	Innovative
		Creative Environment survey
Capability to do something	A manager's ability to achieve the set goals and objectives	
		Social culture
Capability to understand	execute and manage business according as per set target	
		Network
Capability to acknowledge	Meet business goals	Entrepreneurship skills
Potential	Potential of business to grow	Opportunity
Able to solve problem	Able to manage business well	Cost
Capability to analyze	Ability to promote through customers	Source
Capability to prosecute	Make customers' feel personal touch and care	Cutting edge product
Capability to plan	Treat customers like family	Technology
Capability of an individual in achieving a goal or objective	The ability to achieve success and expansion of business when customers spread success story of company to others	Marketing skills
Capability that is aligned to the vision and mission		Competition
Ability to perform a certain task	Strength in manage by thinking skills, perseverance, and commitment	Procedures
Ability to outstand better than others		Management
Thinker, outside of the box/multi boxes, risk taker, innovative, think different, knowledge competence	Having knowledge the function of each department and business you are dealing with.	Customer
		Product differentiation
Strength in thinking skill, perseverance, commitment	----	----

2.8 Conclusions from Literature Review

The literature review uncovered different aspects that are relevant to case study and can be considered for implementation after appropriate measurement and modifications. However, because of fiscal and technological lacking, feasibility regarding experimentation and implementation is very low. Hence by keeping in mind the objectives of the research, it is not recommended to adopt such technologies and techniques which are currently not fiscally viable for the industry.

Meanwhile researches which are focused on; quality, environment protection, ergonomics, organizational work climate and competency of SMEs can be considered since they are more dependent upon the rules, regulations and managerial practices. Bringing changes in these industrial aspects can promise beneficial outcomes, but these changes are difficult to implement and maintain initially and their outcomes can take time to reach the level of tangibility and measurability.

CHAPTER 3: ANALYSIS OF THE LAUNDRY AND DRY CLEANING FACILITY

3.1 Gap Analysis and Preliminary Observations

The first step in the analysis is to understand the system, which is under observation and critical aspects which are relatively undermined and needed attention and improvement are selected and separated for further analysis. These gaps are briefly describe in this chapter and selected gaps are the focal points of the research. Overcoming and improving these gaps will result in improving overall system performance and energy efficiency.

This laundry and dry cleaning facility has a single central unit (factory) and the products are collected from rest of its branches and franchises. These branches and franchises only deal with booking and delivery of the products while all the cleaning services for these products are performed at the central unit, which have number of aspects related to equipment, machines, employees and customers that can be improved or modernized. These aspects are briefly identified as following.

3.1.1 Customer Related

Customer is the stake holder from which revenue is generated and hence it is critical to maintain good relations with each customer. Quality assurance of services, customer complaints/feedback and their satisfaction should be properly addressed for the sake of company's reputation and marketing,

3.1.2 Employee Related

As the industry under observation is not equipped with automatic machines, it is more dependent upon its employees for the proper execution of processes. Therefore assigning them on the bases of skill and interest, their feedback, ergonomics and giving benefits and bonuses will affect their performance.

3.1.3 Consumables, Waste and Recycling

These all three are interlinked and one come after another in a sequence. Consumables involves: chemicals, resources like water and natural gas, equipment and machines. Which result into waste in the form of water pollution, waste from boiler (steam generator) in the form of heat and steam, and scrap from maintenance and repairing machines. Recycling or reduction of above mention byproducts and wastes can reduce cost and consumables used in different activities and processes.

3.1.4 Energy Conservation

Energy is another aspect that is one of the most concerning element of existing era and especially for developing countries like Pakistan that is already facing crisis due to lack of energy. Hence energy conservation should be first priority for industries that relies on machines that run on electricity and natural gas. Laundry and dry cleaning machines use 2-7 horse power motors and a large quantity of natural gas is consumed in steam generator.

3.1.5 Marketing and Business Expansion

Marketing is the activity, set of institutions, and processes for creating, communicating, delivering, and exchanging offerings that have value for customers, clients, partners, and society at large whereas business expansion is the process of pursuing strategic opportunities by developing new products, entering into new markets and forming business partnerships with other companies.

With respect to the case under study, marketing strategies should concern with attracting new customer, encourage them to buy company services and giving promotional offerings to retaining customers, ensuring that the customers continue to buy company services in the long run by safeguarding them against competition. Strategies are discussed in heading 3.2. In regard to business expansion, new company branches and franchises would be the best course of action.

3.1.6 Inventory and Workshop

Inventory and workshop are envisioned with respect to the system reliability and system process flow continuity. Assuring that the system can operate continuously without getting in to the trouble of halting because of malfunctioning of a machine or maintenance and repair, one must have inventory and workshop on standby. Otherwise the recoil of system breakdown will be in the form of loss of revenue and resources.

3.1.7 Automation and Worldwide level of Progress

Automation is the backbone for the developed countries, it along with mass production, accuracy and precision also ensure quality assurance (QA), energy conservation and system reliability as a side product. However its initial cost is very high, because of which it is challenging and even impossible for developing countries to economically balance the odds in this regard.

As the industry under observation is using obsolete equipment and machines and cannot afford to invest large capital in buying new automated machinery instead it can retrofit present machinery with AC drives (VFD) or control systems like programmable Logic Controller

(PLC), so that it can gain some advantage by reducing the consumables and energy consumption.

3.2 Analysis of Marketing Practices

With respect to the case under study, marketing strategies should concern with attracting new customer, encourage them to buy company services and giving promotional offerings to retaining customers, ensuring that the customers continue to buy company services in the long run by safeguarding them against competition. Field observations and interviews provided the information described below.

3.2.1 Practices in Current Use

The Industry was established more than three Decades ago and it has 10 outlets other than head office branch and factory in the twin cities Rawalpindi and Islamabad, however it still relies upon primitive marketing practices. Dependent upon its publicity attained over age and good will with customers

The only practices which are the same as those inbuilt in any business are banners on Franchises/Branches, Monograms on its delivery vehicles, Monograms on its packing materials, Visiting cards on their outlets, Website as a formality of modern era which does not have any online booking or any information about service fee charged by the company.

3.2.2 Contemporary Practices

Contemporary marketing strategy involves use variety of practices and has number of different ways to target general customers as well as specific customer that can generate relatively large revenue in compare to revenue generated by large number of general customers. With reference to present case study general public is the general customers while specific customers are those who need services for mass number of products. For example hotel, marriage halls, Marquee, hospital related clients which need services for large quantity and after a particular time period on contract bases for a year or so. Some well-known as well as specific marketing strategies used by servicing industry are listed in the table 3-1.

Table 3-1: Contemporary Market Practices

CONTEMPORARY MARKETING PRACTICES	
Seeking fixed clients	Seeking franchises
Billboards / Street banners	Opening branches in new towns/societies
Seeking regular customers	Membered customer discount
Discount Cards	Advance payment packages
Bulk discount	Using SMS services
Monthly / weekly packages	Hiring Marketing agencies
Online Booking – pickup – delivery	Mobile applications
Publicity at Branded clothes shops	Annual / seasonal discounts
Monthly lucky draw / gift packages	Using electronic Media (television, e-news)
Using social Media (google add, Facebook etc.)	Giving gadgets/sovereigns like key-chain, calendar, and wall clocks
Using print Media (Magazine, newspaper)	Participation in industrial Exhibitions
Advertisement on Cable network	Marketing through advertisement vehicles
Distributing Pamphlets / leaflets	Launching Industrial projects for graduate level students
Distributing discount cards	Launching tenders

3.2.3 Conclusion and Scope for Improvement

For an industry which has been struggling and gained its reputation by providing quality and satisfaction to customers, over a time duration of three decades, need to be very specific and directive in its future goals and must use marketing strategies accordingly.

The best course would be expanding business and focusing on customers because it is inevitable to remain confined in a specific area for so long and not availing opportunities in other markets. The demand of the modern market is to grow in business, as more resources of revenue increases reliability and creates chances to expand. Practices like hiring marketing agencies, seeking franchises and opening branches in new towns/societies will definitely bloom the business and competitor advantage.

3.3 Process Flow Analysis

Process flow analysis (PFA) is used to help understand the current condition of any process. It draws upon waste eradication, value adding services and visual management techniques, to map out an accurate representation of the current processes. Hence able to identify areas for improvement activities. For the PFA, literature review, field inspection, Interviews and questionnaire surveys were conducted. Together, the information collected created a multiple source of evidence and a broad information platform.

At the end of the analysis a significant amount of date was collected. Two main industrial units, factory and head office branch were the focus of the study, that includes work force of total 43 people, alongside having different equipment and machines for ironing and steaming, all together 30 plus units. For the washing and dry cleaning process a total of 26 active machines are present. Descriptive data is in the upcoming headings.

3.3.1 Human Resource

The work force is divided into different department on the bases of their work. There are 43 people as work force and these are the total number not a sample size, present at two main branches factory plus factory-outlet and head office. Interviews and questionnaire surveys were conducted on total human resource present in the factory and head office branch. Table 3-2 shows department wise distribution of human resource.

The name of the department are as per used by the company itself. Moreover each department has a manager (MG.) which is included in the count for human resource.

Table 3-2: Human Resource

Department	**Accountant**	**Counter man**	**Branch Product Auditor**	**Press man**	**Supervisor**	**Wash man**
Acronym	Acct.	C.M	O.K	P.M	SPR.	W.M
Human Resource	2	10	8	15	1	7

3.3.2 Machine and Equipment

All the machines are man operated i.e. not automated. These machines varies in numbers, size, capacity and functionality (see table 3-4, 3-6). Machines are used as per the load or number of products, especially during seasonal load at beginning of each season, summer and winter.

3.3.3 Consumables

All the consumables are associated with the washing and dry cleaning process. In case of washing, water act as a solvent while additives like cleaning agent, bleaching agent and softener are the main consumables. While in case of dry cleaning a petro-chemical act as a solvent and at the same it works as a cleaning agent without adding any other additive, hence the same petro-chemical is the consumable in dry cleaning process.

3.3.4 Utilities

There are three main utilities which provide the necessary power to run the industry. First is the electricity which powers the machinery and equipment, second is the source of heat generation the natural gas and the third is the water resource that provides the medium for cleaning services. Electricity is utilized by mainly laundry and dry cleaning machines, there for its consumption is directly proportional to load of product, more number of product will require more machines running at a time, hence more electrical energy. A twelve month recode provided by the company shows that electrical consumption varies between 3280 - 6240kWH while giving an average of 4760kWH and maximum demand indicator (MDI) ranges from 36-47 kW with an average of 40.67kW.

Natural gas is used in steam generator, steam laundry and steam pressing both consume large amount of steam. It is also directly proportional to load that required steam pressing. Companies 12 month record shows consumption variation between 179.2 - 282.14 MBTUs, average value at 218.76MBTUs per month.

Water as a resource is very essential for any service that is related to cleaning of textile products. In this case water is used in steam generator and laundry, a working fluid for both cases. Since no metering device is attacked for water consumption, an interview based approximation is considered, department manager claims an average of two water storage tanks are consumed, tank has dimension of $24\times14\times3.5$ $ft^3 = 1176$ $ft^3 = 33.30061$ m^3, that is equivalent to 33300.61 liters, two times this amount (66.6 m^3/day) is the average consumption.

3.3.5 Processes and Activities

A product goes through different processes before finalized as refurnished product for delivery. Other than type of cleaning method and ironing/steaming process other activities are similar like packing of serviced product or handling of product during delivery to outlets. Average time of each activity is utilized in the simulation process discussed in chapter 5, for better understanding of the service process and system, only the activities in different processes are describes in this chapter.

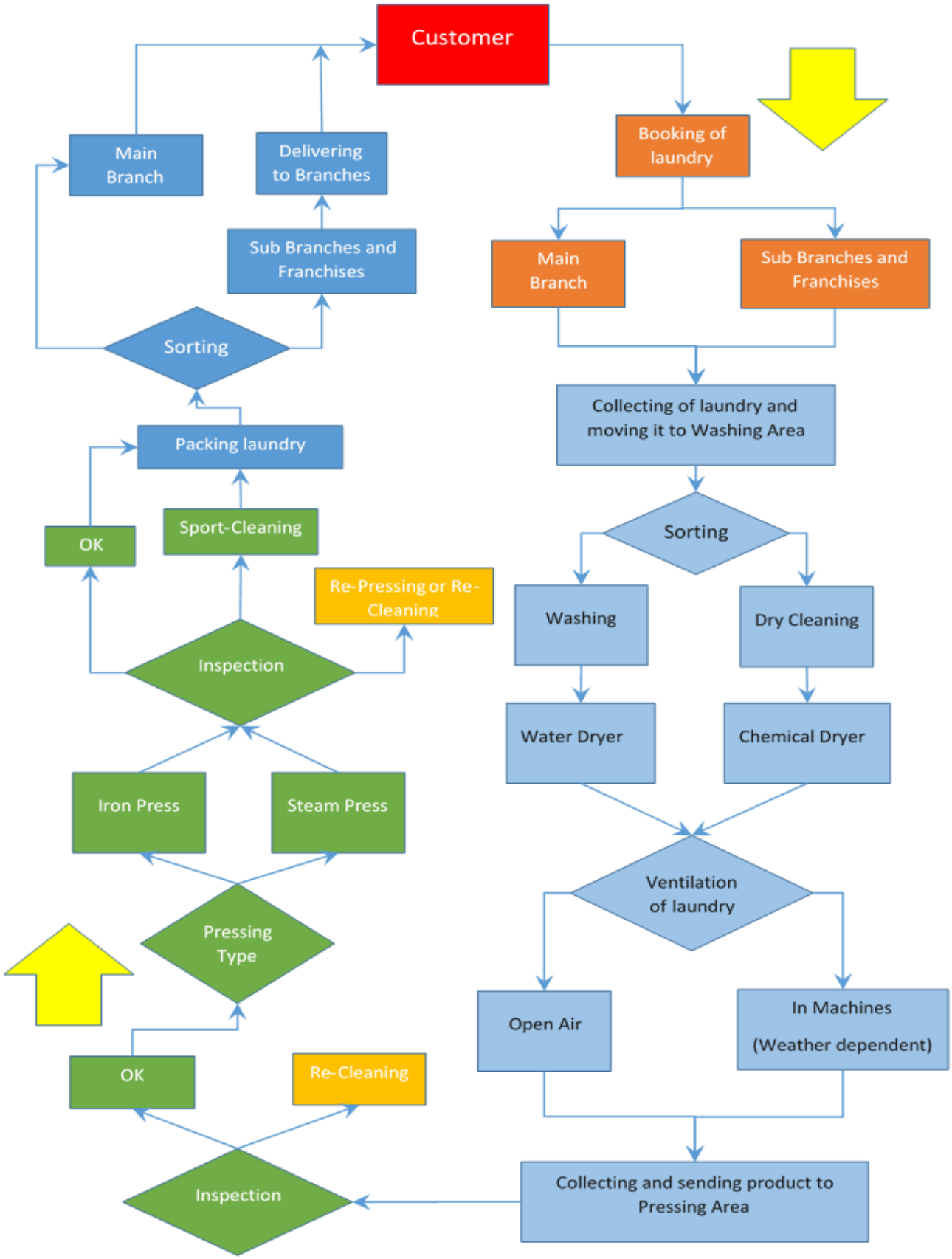


Figure 3.1: Flow Chart

Figure 3.1 shows the whole service process including sub-processes, their details are as following.

3.3.5.1 Booking of Products

The first step involves the booking of products directly form the customer. These products are tagged according to the receipt number or booking number. These tags are of different color which identify the branches from where the products is being booked. For collecting products from the branches which are to be serviced, loading vehicles (also delivery vehicles) are used which collect the new batch (to be cleaned) and delivers the cleaned batch which was collected previously. This process is cyclic and performed every working day.

3.3.5.2 Sorting and Moving to Washing Area

This is the second phase of the process, collected products are transported to the factory where they are sorted on the bases of color of the clothes, fabric type and cleaning method. Usually products are transported by night and then next morning this process is conducted.

3.3.5.3 Cleaning Process

Just after sorting cleaning or washing process starts in the morning of each working day. This process comprises of number of activities, depends upon cleaning method as shown in figure 3.1. During this process product are cleaned in batches.

Washing process involves manually loading the washing machine with products, water and cleaning agents. All the switches, valves and lifting of products are controlled and transported by means of hand and hand trolleys respectively.

Dry cleaning process is alike with respect to manual or labor work, however special machine which can handle dry cleaning solvent (chemical) are used without which this process cannot be completed.

3.3.5.4 Drying and Ventilation

It is necessary to dry the products which are cleaned after washing and dry cleaning process. Surplus solvent socked by the products (clothes) is extracted by means of separate spinner machines. Again all the lifting, loading and operating is carried out manually.

Spinning process uses centrifugal force to force out solvent out of the products while they rotate at high speed in the spinning machine. About 50% of the socked solvent is removed during this process. For complete drying, dryer machines or ventilation is necessary. Ventilation is done by manually hanging the products on the roof, under the sun rays and open area. Not more than an hour is enough for ventilation process.

3.3.5.5 Recollection and Moving to Pressing Area

Dried clothes are recollected and moved to the pressing area, where different machines and equipment are used for ironing/steaming the product. Here in this process individual piece

is handle by the press man (P.M), see table 3-1. As each product is worked upon by a person, inspection for defects and not properly cleaned product is also ensues. There are different pressing methods iron and steam press, which are selected as per the type of product and fabric, for example, Dress Pants/Coats are steam pressed while cotton clothes are hand-iron pressed.

3.3.5.6 Re-cleaning (RC)

It is part of inspection at the later stage when after iron/steam pressing, a sport or defect is still visible on the garments. A sport cleaning activity is applied and if the defect is removed it moves to the next stage otherwise send back to the washing department for re-cleaning.

3.3.5.7 Packing and Delivering:

After pressing the products are packed by manually operated machines which core the products with a thin plastic sheet. Here comes the role of O.K personal, each person is responsible for auditing products of a specific outlet. During this audit each product is separated with respective to its outlet, by using the tags attached to that product. O.K personal is also responsible for finalizing and grouping all the products which were previously collected from a branch and then loading them on the delivery vehicles. Delivering these product back to their respective branches/outlets is the last activity of the whole process.

All the above mention sub-process under the heading 3.3.6 are executed in a single working day and all of these sequentially makes a complete process cycle of a day, shown in figure 3.1.

3.3.6 Area wise Distribution of Processes

Another aspect related to the industry was to study area wise distribution of processes, in short how much area is assigned to a particular department with respect to the whole area of the facility. This kind of study help in understanding physical positioning of activities and processes, constraints, bottle necks, unused and useful locations that can be utilized for bring changes and improvements in the system. Further details related to industrial area and schematic dimensionless area distribution of each floor is given in the appendix A, from ground floor to the top roof of the industry.

3.3.7 Conclusion and Scope of Application

Standard Operating Procedures (SOPs) for each process must be define and implemented on hard and fast bases, so that every employee can perform accordingly and in same manner. End justifies the means, is totally against professionalism. That is why SOPs sets the ground for quality assurance and increases level of ergonomics and safety of employees.

In a process flow, time is asset and it should be maintained for each activity to make sure continuous flow of process and time. Activities that can be made time efficient will reduce

the time period of whole process and reduce consumptions of utilities, consumables and use of machinery and equipment.

Ergonomically it must be kept in mind that all the activities are manually done and operated by employees, their work load should not affect their performance as quality of the services performed on products is directly linked with the employees performance.

Area wise distribution of different department had gone through changes in the past, over the time period of three decades, now the facility cannot meet the expense of going into major change on system level, however within the department changes can be done for effective area management or installation of any new equipment that can improve the performance of process.

The number of product that comes in RC (re-cleaning) can be used as an indicator of the system performance. Less or minimum number of RC products will show improved performance otherwise it has gone worse as the number of RC products increases.

3.4 Analysis of Quality

This part of analysis holds a significant position in the whole study. From the point of product and services, quality indicated the compliance with the design variables, standards and customer satisfaction. At time quality plays a key role in comparative advantage over the market competitors.

In this age, every nation concerns itself with a high standard of living and better quality of work life and every organization concerns itself with high profit levels and an increased market share. For consumers who are concerned with the quality or "fitness for use" of the goods and services offered, therefore, productivity and quality management constitute the major driving force for survival.

Productivity and quality move together side by side, both hold equal importance in industrial engineering. Descriptive notes on quality and productivity related terminologies is given in the upcoming headings.

3.4.1 Productivity and Quality

Productivity was mentioned for the first time in an article by Quesnay in 1776 and since then many authors have defined it in different ways. A careful examination of these definitions reveals the one major similarity that most authors viewed productivity as a 'measure' of output, to one input, two inputs, or total input. The measure also pertains to how well resources are utilized. For the purpose of this text and understanding, the three forms of productivity are define as follows[28]:

I. Total productivity is “the ratio of total output to all input factors.”

II. Total factor productivity is “the ratio of total output to the sum of associated labor and capital (factor) inputs.”

III. Partial productivity is the “ratio of total output to one class of input.”

Quality is also defined in different ways over the period of time. One of them is “conformance to requirements” defined by Crosby (1979) however this definition required clarification of all relevant quality characteristics and total evaluation and understanding of the entity involved. Juran (1979) defines quality as “Fitness for use”, the inclusion of the concept of the user is a unique aspect of this definition, and quality requires every member of the organization to provide the next person in the process with an acceptable product or service. Juran further identify four important parameters of fitness for use as[28]:

I. Quality of Design

II. Quality of conformance

III. The abilities

IV. Field service

The interrelationships among these parameters are shown in Figure 3.2 [28]. Fitness for use can be described as ability to process and produce with less rework, less scrap, minimal downtime, and high productivity.

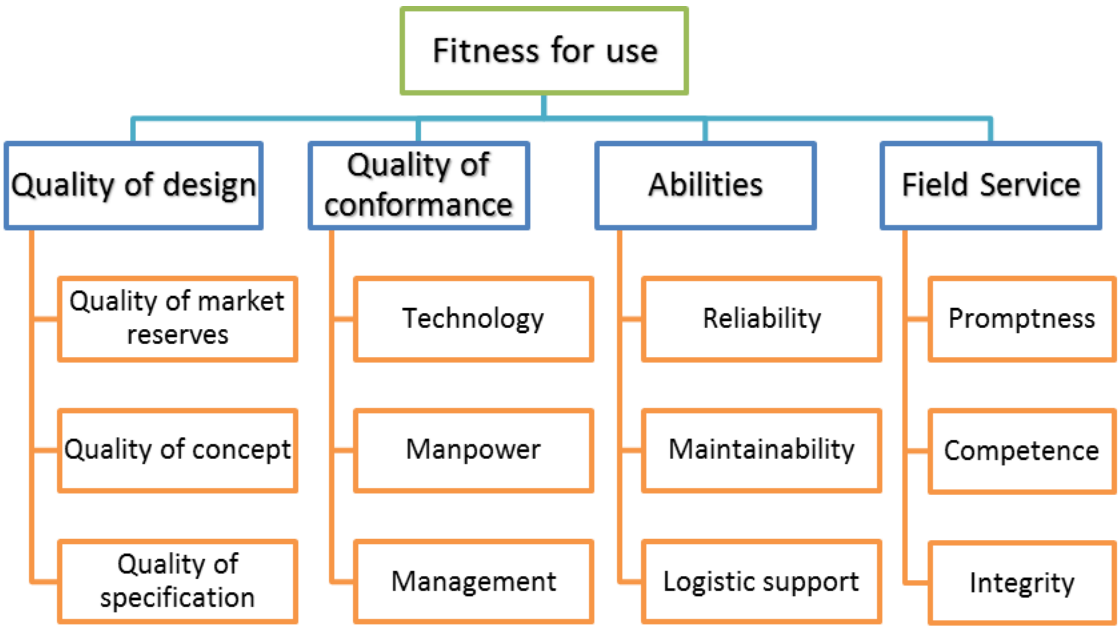


Figure 3.2: Interrelationship between quality parameters

3.4.2 Quality Characteristics

These are the elements of fitness for use that typify the variety of uses of a given product or service. They may be of several types [28]:

I. Time-oriented (serviceability, reliability, maintainability)
II. Sensory (color, taste, beauty, appearance, and others)
III. Structural (including frequency, weight, length, and viscosity)
IV. Commercial (warranty)
V. Behavioral or ethical (fairness, honesty, courtesy, and so on)

Quality has different meanings to different people depending who is involved. The fact, views, and perception on quality are summarized in the table 3-3 [28].

Table 3-3: views, perception, and fact on quality

Total Quality Management View	**Traditional View**	**Quality in Perception**	**Quality in fact**
Productivity gains are achieved through quality improvement	Productivity and quality are conflicting goals	Delivering the right product	Doing the right thing
Quality is conformance to correctly defined requirements satisfying user needs	Quality is conformance to specifications / standards	Satisfying your customer's needs	Doing it the right way
Quality is measured by continuous process / product improvement satisfying user needs	Quality is measured by degree of nonconformance	Meeting your customer's expectations	Doing it right the first time
Quality is determined by product design and is achieved by effective process controls	Some defects are allowed if the product meets minimum standards	Treating every customer with integrity, courtesy, and respect	Doing it on time
Defects are prevented through process-control techniques.	Quality is achieved through inspection	____	____
Quality is part of every function in all phases of the product life cycle.	Quality is a separate function and focused on evaluating production	____	____
Management is responsible for quality	Workers are blamed for poor quality	____	____
Supplier relationships are long-term and quality oriented	Supplier relationships are short-term and cost-oriented	____	____

3.4.3 Perspective of Quality

The history of quality management, quality improvement, quality assurance and other quality related aspects shows that there have been researchers who have formulate philosophies of quality, each with their own different approaches and described different aspects that have a direct impact upon the quality of an organization or a company. Appendix B contain tables related to strategies for implementing quality programs, three philosophies and a table of Crosby's Quality Management Maturity Stages[28].

3.4.4 Qualitative Analysis of Quality

Analysis of quality can be further divided into two parts, qualitative and quantitative. It must be noted that both parts were necessary as quality itself is non-measurable at some point like human behavior, motivation, and opinions, whiles on others it can be linked to level of non-compliance to the standards or customer needs, hence measurable relatively.

Moreover the system under study is mostly human controlled and operated, bound to face man made errors and defects hence quality is also directly affected by performance of work force employed. It is not possible to achieve desire quality services without taking account of the human factor that is responsible for performing those services.

Figure 3.3 representing the data acquired by qualitative analysis of the facility. Critics and conclusion is given separately, under heading 3.4.6.

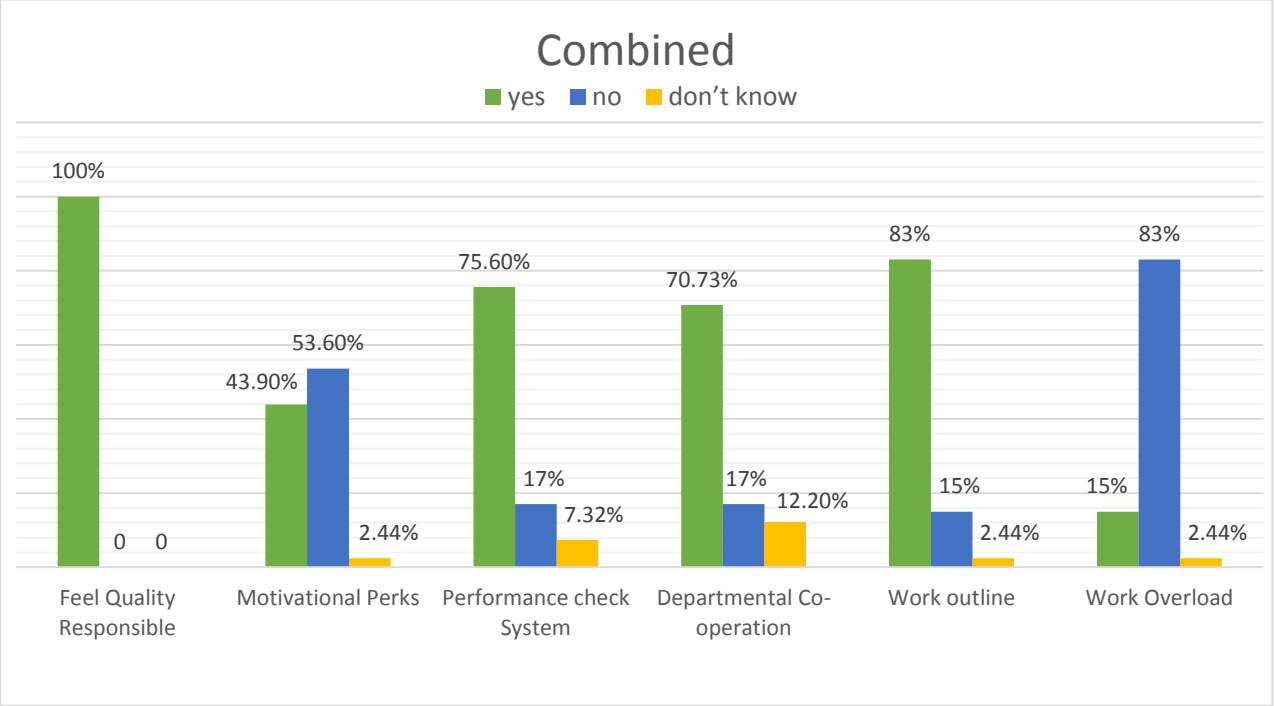


Figure 3.3: Qualitative Results

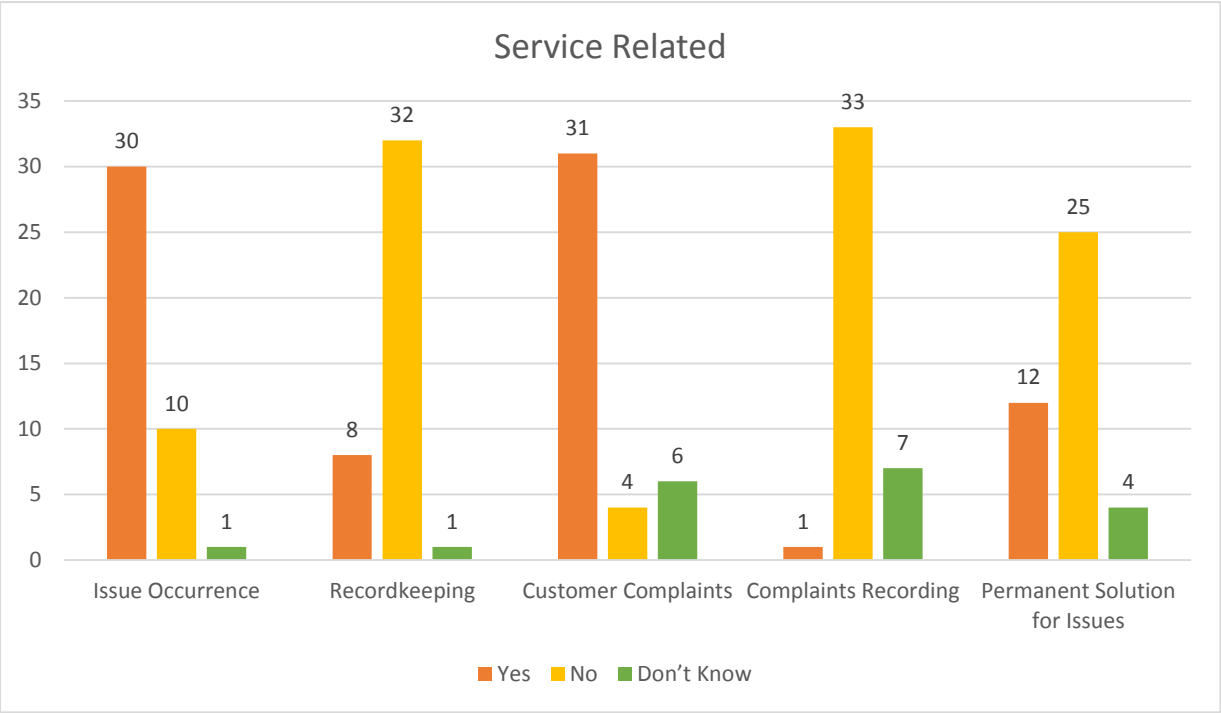


Figure 3.4: Quantitative Results

3.4.5 Quantitative Analysis of Quality

The word quantitative itself demands for numbers, values, facts and figures that can be directly linked with some predefined or perceived value which is unaffected by the changes in qualitative parameters such as human emotions, performance. The results are easy to infer as the mode value in the data set becomes the results of the analysis. Figure 3.4 have different sets of data in the form of bar graph, conclusions and deductions are in succeeding heading.

3.4.6 Conclusions and Deductions

Job benefits and allowances are being considered motivational perks however motivational perks are focused upon performance, efficiency and quality produced by an employee.

Things like performance checking system and outline of a job are carried out through simple observations and verbally respectively. No records and organized logical outline is defined in such regards.

Rate of quality related issues is significantly high. Frequently occurring issues are considered common issues, according to employees' personal views.

From the personal comments of the employees, most of them have bluer concept of quality while at the same time they all are responsible for quality since everyone in linked with a process of the service cycle, shown in figure 1.1.

3.5 Analysis of Energy Consumption

Modern age is converging towards more energy efficient and conservative solutions while simultaneously raising the standards of living and reducing environmental contamination. Every developed country of the globe is in continuous struggle to reduce energy consumption and at the same time increase productivity, their high gross domestic product (GDP) proves their effective energy management and self-sufficient. On the other hand developing countries which are facing energy shortage must concentrate on effectively managing energy consumption so that they can reduce the risk of facing an energy crisis.

The current case of laundry and dry cleaning facility has a large number of equipment and machines which are the sole consumer of energy in the whole facility. Serial number of machines are as per the location in the washing/dry cleaning department, while in other departments numbering is independent of location of the machines and equipment.

All the services offered by the company consumes significant amount of energy and working hours of the workers / employees. Table 3-4 shows energy consumed by various machines used by the facility. The information on energy consumed by the whole facility is given in the previous heading 3.3.4. At any instant of working hours, it is improbable to have maximum energy consumption i.e. each and every machine being active at the same instant. The maximum demand indicator (MDI) ranges from 36-47kW with an average of 40.67kW, while the maximum electrical energy the facility can exert is the three times of average MDI.

3.5.1 Conclusion

The washing and dry cleaning department has the maximum consumption in compare to any other department, more than twice of any other. Hence any change in the utilization of energy in this department will significantly improve the consumption of the system.

Comparing the size and number of batches a small hydro-extractor can service to that of a large hydro-extractor at a given time period, can help us in deciding which extractor should be used under which conditions, since the large extractor require more than three times the energy as that of the small extractor.

Some electrical load cannot be altered like that of the steam and iron pressing machines and equipment. There is very little gap for improvement under present situation. Slowly replacing the old equipment with the new and improved ones will definitely be more feasible with visible effects with regards to ergonomics, efficient and energy conservative.

Table 3-4: Energy Consumed by Machines

Sr. no.	Machine type	Loading Type	Amperage (A)	Energy (kW)		Total Energy (kW)
Washing (Power Factor = 0.8)						
1	Tumble Dryer	Front	4.5	2.49		56.67
2	Tumble Dryer	Front	6.8	3.76		
3	Belly washer	Top	7.5	4.16		
4	Washer	Front	3	1.66		
5	Washer	Front	1	0.55		
6	Washer	Front	1.5	0.83		
7	Washer	Front	2.5	1.39		
8	Washer	Front	1.5	0.83		
9	Washer	Front	1.5	0.83		
10	Belly washer	Top	1	0.55		
11	Belly washer	Top	6	3.32		
12	Belly washer	Top	1.5	0.83		
13	Washer	Front	2	1.11		
14	Belly washer	Top	3	1.66		
15	Blanket-Washer	Front	9	4.98		
16	Stark-Hydro-Extractor	Top	2.5	1.39		
17	Hydro-Extractor	Top	6	3.32		
18	Belly washer	Top	12	6.65		
19	Stark-Hydro-Extractor	Top	5	2.77		
20	Hydro-Extractor	Top	15-20	8.31-11.09		
21	Blanket Dryer	Side	2.7-4.5	1.5-2.5		
Dry Cleaning (Power Factor = 0.8)						
1	Chemical-Extractor	Top	5	2.77		14.12
2	Dry-Cleaning-Machine	Front	7	3.88		
3	Tumble-Dryer-chemical	Front	3.5-4.5	1.94-2.49		
4	Tumble-Dryer-chemical	Front	3.5-4.5	1.94-2.49		
5	Tumble-Dryer-chemical	Front	3.5-4.5	1.94-2.49		
Electric and Steam press (Power Factor = 0.9-1)					**Sets**	
1	Electric steam Iron	Single piece	5.2	1.2	8	28.93
2	Electric iron	Single piece	7.3-9	2	8	
3	Steam press	Single piece	0.3	0.069	4	
4	Dry clean press	Single piece	0.3	0.069	6	
5	Collar-Cuff-Press	Single piece	0.3	0.069	2	
6	Multi-Form-Finisher	Single piece	2.5	0.550	1	
7	trouser-form-finisher	Single piece	3.5	0.725	1	
8	universal form finisher	Single piece	3.5	0.725	1	
9	Plastic-Covering station	Single piece	1.1	0.250	2	
Other Electrical Load (Power Factor = 0.8)						
1	Elevator	---	7.5	4.16		28.57
2	Boiler equipment	---	6	3.32		
3	Air compressor	---	20	11.09		
4	Air conditioner, fan, light	---	---	5-10		
Total energy consumption (maximum) in kW						128.29

3.6 Load Parameters

The products which are loaded in machines have variable mass, depends upon the water content absorbed by it. As the product goes through different processes which lead to three possibilities; dry product before washing, wet product after washing and moist after going through hydro-extractor. The types of product (table 1-4) and the seasonal products also vary in weight. The present seasonal products are listed below in table 3-5 along with their average mass. Only those products are considered which comes in large number and frequency, having more than significant share in overall load. Some washing machines are mostly used for products with heavy mass, number of blankets loaded in them is considered as loading criteria for such machines. This loading criteria is not based upon the design variables of the machine, just something company came up with on its own, developed over time.

Table 3-5: Different Masses of Loaded Items

Sr. no.	Products		Dry Mass (kg)	Moist Mass (kg)	Wet Mass (kg)	Per Suit, Total mass (kg)		
						Dry	Moist	Wet
1	Kameez / Shirt		0.245	0.425	0.550	0.495	0.82	1.115
2	Salwar		0.250	0.395	0.565			
3	T-shirt		0.200	0.295	0.445	0.835	1.365	2.010
4	Jeans		0.635	1.070	1.575			
5	Pent		0.380	0.500	0.885	1.49	1.935	3.915
6	Coat		0.755	0.875	1.770			
7	Waistcoat		0.355	0.560	1.260			
8	Ladies fancy dress		0.735	1.085	1.680	0.735	1.085	1.680
9	Blanket	2-layers	4.615	6.520	11.010	7.835	11.06	18.545
		1-layer	3.220	4.540	7.535			

3.6.1 Conclusion

The different masses of the products will be used to acquire an average mass of load being serviced by a machine. It is true that the seasonal products are selected but the quantity of mass is irrelevant to that of the product type, moreover the selected products like pent and coat are used in every season.

Parameters like shape, type and fabric of the product are more useful when the focus of interest is quality not quantity. These parameters can be used as pointer for deciding which service method will be best for a particular product.

3.7 Machines Loading Criteria

The facility uses its own loading criteria, which is based upon the number of pieces of the clothes that can fill the volume of a machine up to its water mark. The type and shape/form of the product itself determine the number of that product loaded in a particular machine. As

mentioned previously that the machines are mostly reconditioned and their design specifications are missing, the internal drum / cage of the machines are measured using an inch tape. These dimensions are compared with the respective type of machine whose specifications are given by their manufacturer internationally on the internet. These comparative dimensional analysis help in determining the capacity of that machine and at the same time data on loading criteria used by the company is collected by means of field research of facility and interviews of employees, see table 3-5 and 3-6 for reference. The load calculated by using table 3.5 is based upon those garments which are frequently loaded in a particular machine. Some of the average load is expressed in a range between two values because two types of garments are being loaded in separate batches, each having its own unique mass

Table 3-6: Load and Capacity of Machines

Sr. no.	Machine Type	Cage size inch(mm)		Machine Avg. Load		Rated capacity (kg)
		Diameter	Width / height	no. of pieces of clothes	In (kg)	
1	Tumble Dryer	42(1067)	41(1041)	100	41-65	50
2	Tumble Dryer	42(1067)	41(1041)	100	41-65	50
3	Belly washer	36(914)	90(2286)	18 Blankets	70.5	100
4	Washer	42(1067)	34(864)	200	49.5	75
5	Washer	30(762)	21(533)	10 Ladies Suits	7.35	20
6	Washer	35(889)	25.5(648)	150	37-74.5	47.6
7	Washer	35(889)	25.5(648)	150	37-74.5	47.6
8	Washer	28(711)	15(381)	5 Ladies Suits	3.675	10
9	Washer	28(711)	15(381)	5 Ladies Suits	3.675	10
10	Belly washer	41(1041)	40(1016)	10 Blankets	39.18	----
11	Belly washer	40(1016)	58(1473)	15 Blankets/300	74.25	----
12	Belly washer	33(838)	42(1067)	200	49.5	70
13	Washer	36(914)	27.5(699)	100	24.75	45
14	Belly washer	32(813)	38.5(978)	100	24.75	50
15	Blanket-Washer	28(711)	42(1067)	18 Blankets	70.5	100
16	Stark-Hydro-Extractor	20(508)	9(229)	5 suits	5.6-10.5	10
17	Hydro-Extractor	48(1219)	18.5(470)	250-300	167.25	120
18	Belly washer	42.5(1080)	87(2210)	36-40 Blankets	156.7	200
19	Stark-Hydro-Extractor	35(889)	15(381)	150	83.62	50
20	Hydro-Extractor	59(1499)	19.5(495)	20 Blankets/500	278.75	200

3.7.1 Conclusion

The capacity of machines being deduced through dimensional comparison with their respective type of machines does not specifies the type of garments to be serviced by those machines. However, the present facility follows its own loading criterion which is based upon number of pieces of garments whose average mass in kg is given in table 3-6. To visualize the comparison a line graph is shown in the figure 3.5, mostly machines are loaded below the rated capacity however still few machines are loaded above rated load with significant difference between respective comparing loads.

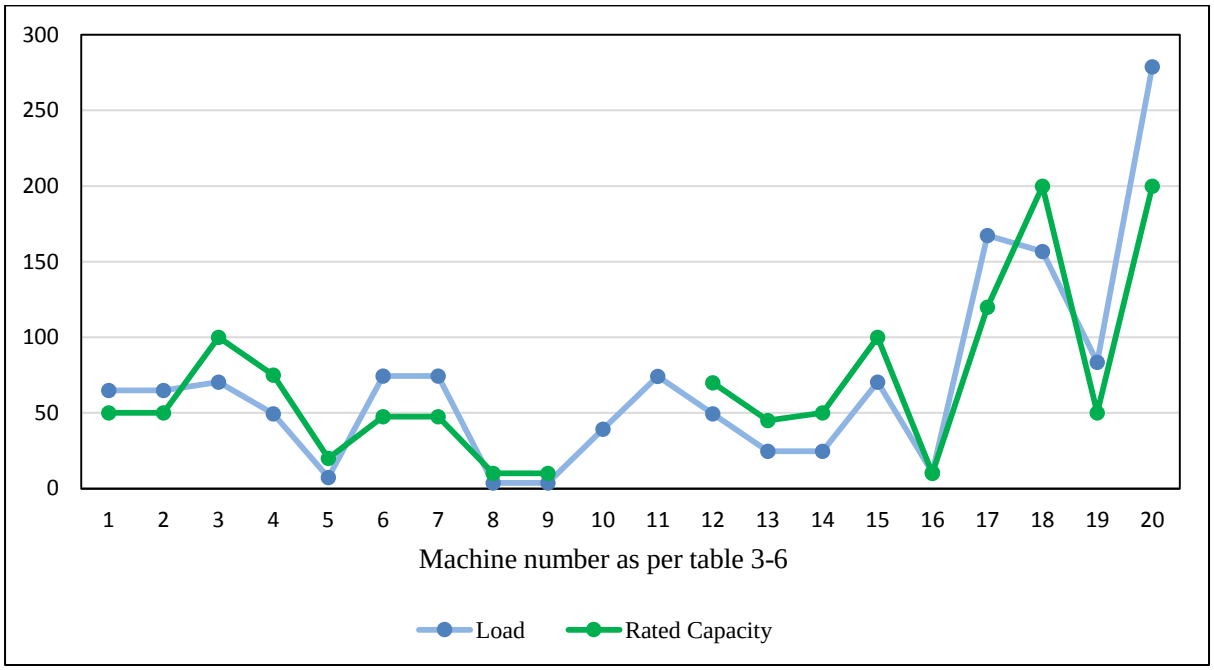


Figure 3.5 : Comparison between Load and Rated Capacity

The type of garments which are loaded must be quantified as per their shape and form because garments like kameez/shirts and tea-shirts with full sleeves tends to tangle together because of their long sleeves, as a result the whole mass of garments swirl as a single mass at the bottom of the drum and separate pieces do not get proper mechanical tumble action which lead to uncleaned garments at the end of the washing process.

3.8 Analysis of Human Resource

Analysis of the work force was conducted by skimming through company data and questionnaire survey. Individual as well as departmental level data is compiled at the end of the analysis.

3.8.1 Company Data

The data provided by the company with respect to the employees contains information regarding employee's department allocation and their date of joining the company, a duration of work experience. Its graphical representation is shown in the figures 3.6 and 3.7 (C).

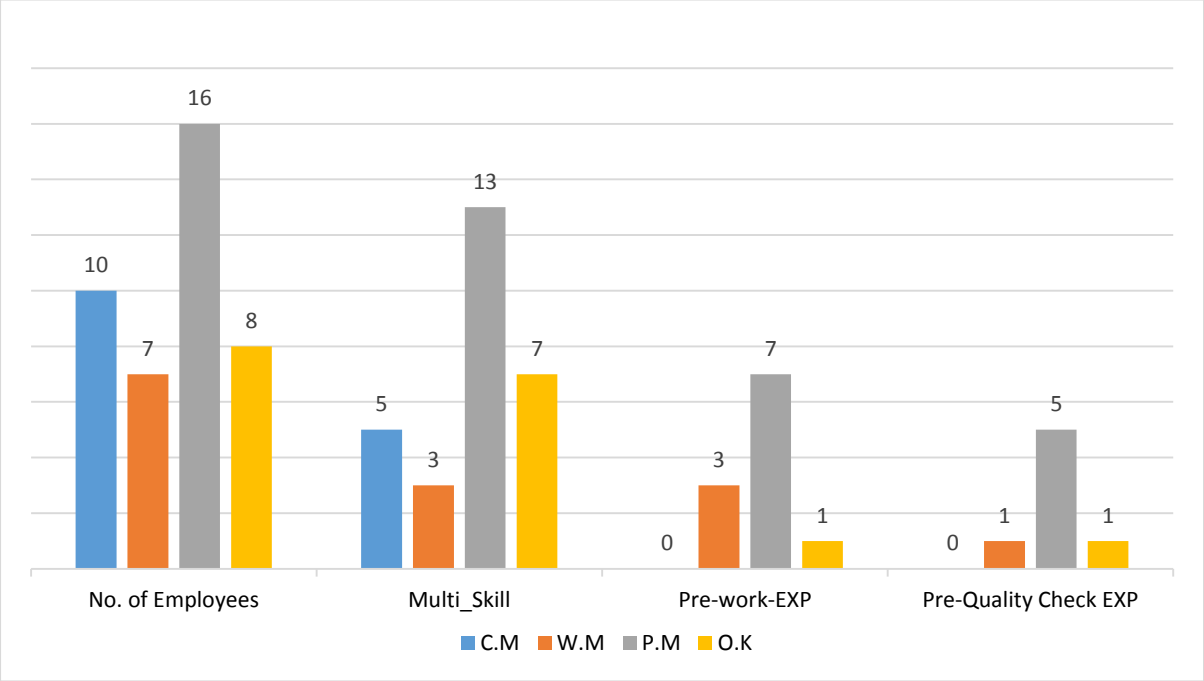


Figure 3.6 : Department Wise Employee Data

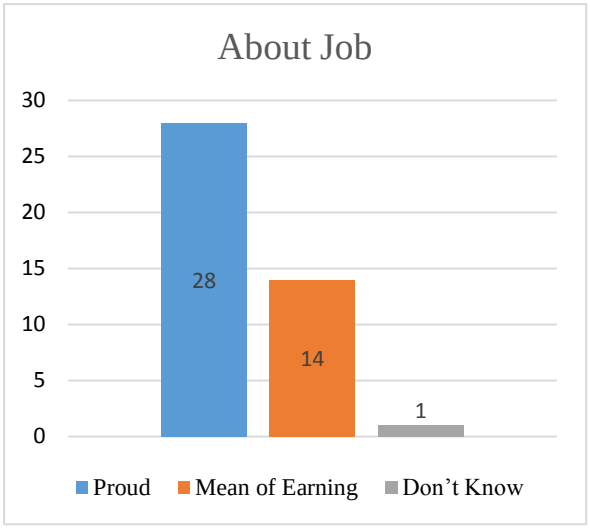
3.8.2 Questionnaire Survey

By means of questionnaire survey, information on employee such as their education level, pre-work experience, and multi-skill level was collected. Data collected through analysis is critical for understanding the type of human resource available and potential in the work force. Collected data is arranged in the form of bar graph and pie chart as shown in the figures 3.6 and 3.7. A part of survey consist of personal opinions of the employees, that cannot be expressed as graphical data collection however those opinions proved helpful in deducing valuable conclusions regarding this part of the study.

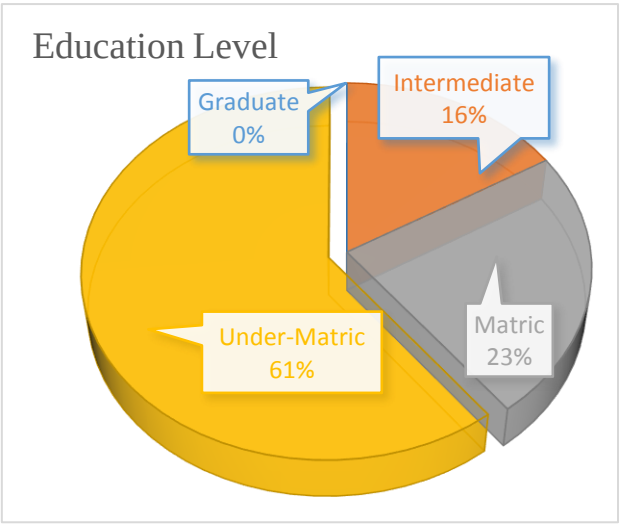
3.8.3 Conclusions

Lack of professional education, learning by doing concept (contrary to developed country), and multi-skill (work experience in multiple machines or department) persons are present in all departments, but their skill is on the bases of learning by doing.

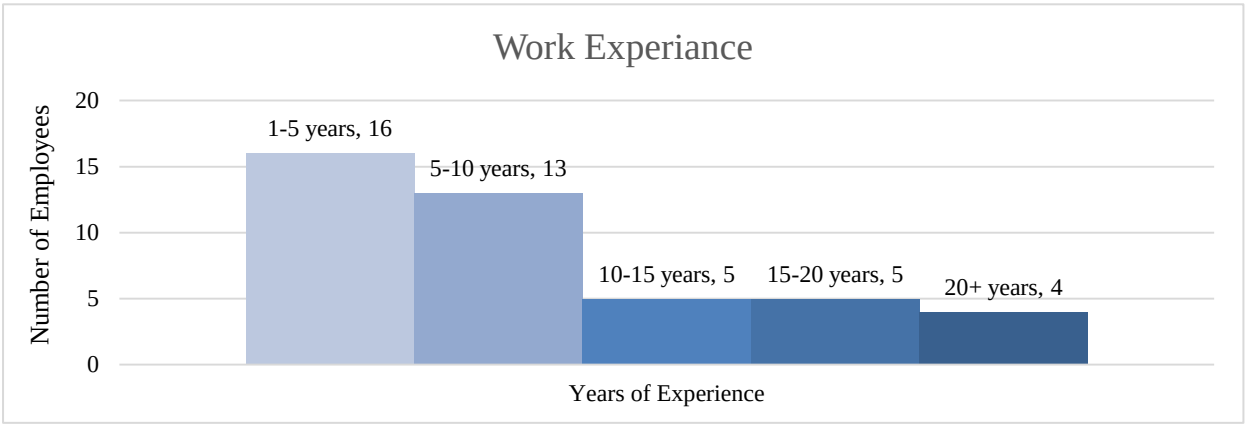
More than 60 percent of the employees are under-matric, making it difficult to make them understand things logically and technically, a layman level of education. Those who have done matric or intermediate (0% Graduates), still lack professional education/diploma.



(A)



(B)



(C)

Figure 3.7: About Job (A), Education Level (B), Work Experience (C)

Those few who claim work experience before joining this industry are no better than having no experience. As during the interviews and questionnaire it was revealed that their previous work environment is similar to the present case. Those who claim that they have done quality checking work before present job, did not have any academic training or education in regard to quality or its aspects, see figure 3.6.

Among the strategies for implementing quality programs, given in appendix B, the employee involvement-based approach, The Customer-Driven Improvement Approach and the total quality systems approach can be practically implemented to the current system under observation. Currently there is no active strategy or defined quality program implemented on the system.

CHAPTER 4: STANDARDS CONCERNING THE CASE STUDY

4.1 Introduction

Creating standards and compliance to standards is one of the major concern in the field of industrial engineering. Developed countries have very strong industrial sector because they do not compromise of standardization, this not only eliminate waste, defects and rework but also give high system efficiency and low cost of products and services without losing any edge on quality.

The standards related to the present case, discussed in this chapter are mostly taken from standards defined by Environmental Protection Agency (EPA) of America and its sub divisions. Different terminologies related to dry-cleaning and laundry sector, found in relative EPA documents are also briefly described in this chapter.

4.2 Terminologies

Different terms related to current research are described in this section, which are mostly taken as reference from United State department of Small Business Administration (SBA) and its sub departments.

4.2.1 Small Business Size standards

Small business size standards are considered and compared to the North American Industry Classification System (NAICS) effective February 26, 2016. These size standards are represented in either millions of dollars (those led by "$") or number of employees (those without the "$"). A size standard is the maximum rating that a concern can attain and still qualify as a small business for Federal Government programs. Usually, size standards are the average annual receipts (total income) or the average employment of a firm[29].

According to small business compliance policy, a small business is a person, corporation, partnership, or other entity that employs 100 or fewer individuals (across all facilities and operations owned by the small business). The number of employees should be considered as full-time equivalents on an annual basis, including contract employees. Full-time equivalents means 2,000 hours per year of employment[30]. Also the number of employees of a business or industry is its average number of employees that are eligible for each pay period over the concern's latest 12 months duration.

Table 4-1 [29] shows the size standard related to the business concerning to present dissertation. The sizing gives the maximum required annual income or in some sectors maximum number of employees that a small business can maintain to remain under the

supervision of U.S. small business administration (SBA). Only the concerning sector and subsector are taken as reference, which are related to this research.

Table 4-1 : Small Business Size Standard as per U.S. department of SBA

NAICS Codes	NAICS Industrial Description	Size standard	
		Millions of dollars	No. of employees
	Sector 81 – Other Services		
Subsector 812 – Personal and laundry Services			
812111	Barber Shops	$ 7.5	---
812112	Beauty Salons	$ 7.5	---
812113	Nail Salons	$ 7.5	---
812191	Diet and Weight Reducing Centers	$ 20.5	---
812199	Other Personal Care Services	$ 7.5	---
812210	Funeral Homes and Funeral Services	$ 7.5	---
812220	Cemeteries and Crematories	$ 20.5	---
812310	Coin-Operated Laundries and Drycleaners	$ 7.5	---
812320	Dry-cleaning and Laundry Services (except Coin-Operated)	$ 5.5	---
812331	Linen Supply	$ 32.5	---
812332	Industrial Launderers	$ 38.5	---
812910	Pet Care (except Veterinary) Services	$ 7.5	---
812921	Photofinishing Laboratories (except One-Hour)	$ 20.5	---
812922	One-Hour Photofinishing	$ 15.0	---
812930	Parking Lots and Garages	$ 38.5	---
812990	All Other Personal Services	$ 7.5	---

4.2.2 Dry-cleaning and Laundry Services (except Coin-Operated) as per NAICS

The industries classified by code 812320, includes concerns engaged in any one or more of the following:

1. Providing services related to dry-cleaning (excluding coin-operated).
2. Providing services related to laundry (except linen and uniform supply or coin-operated).
3. Provide services of drop off and pick up locations for laundries and drycleaners or both.
4. Provide special cleaning services for specific types of garments and other textile items (except carpets and upholstery), such as fur, leather, or suede garments, wedding gowns, hats, draperies and pillows. These concerns may provide all, a combination, or none of the cleaning services on the concerns' sites[31].

Cross-References, establishments mainly involved in:

- Supplying laundered linens and uniforms on a rental or contract basis are classified under Industry code 81233, Linen and Uniform Supply.
- Operating coin-operated or similar self-service laundry or dry-cleaning facilities are classified under code 812310, Coin-Operated Laundries and Drycleaners.

- Cleaning of carpets and upholstery are classified under code 561740, Carpet and Upholstery Cleaning Services[31].

4.2.3 Not Dominant

An industry or business is not dominant in its sector unless it does not inflict a controlling or major influence role on its respective sector. SBA also investigates whether a concern at or below a particular standard would dominate the industry on a national basis. Therefore, any concern at or below the standard size is assumed not to be dominant in its turf[29].

4.2.4 Non-Manufacturer

As per NAICS, a concern that supplies a product it did not manufacture is termed a non-manufacturer. To be eligible for acquiring government contracts that are set aside for a small business, a non-manufacturer must have 500 or less employees, primarily in the wholesale or retail trade. This requirement is called the "non-manufacturer rule." This rule does not apply to supply contracts of $25,000 or less that are processed under Simplified Acquisition Procedures. These requirement may also be waived through formal procedure by the Associate Administrator for Government Contracting if there is no small manufacturer available for that contract[29].

4.2.5 Dry Cleaning[32]

From the documents publicized by EPA, some simplified data is being represented under current context. Dry cleaning involves the cleaning of fabrics with non-aqueous organic solvents. The dry cleaning process requires three steps:

(1) Washing the fabric in solvent.

(2) Spinning to extract excess solvent.

(3) Drying by tumbling in a hot air stream.

4.2.6 Types of Solvents[32]

Two types of cleaning fluids are generally consumed in the dry cleaning industry; petroleum solvents and synthetic solvents. Petroleum solvents, such as Stoddard or 140-F, are relatively inexpensive and combustible hydrocarbon mixtures. Operations using petroleum solvents are known as petroleum plants.

Synthetic solvents are much expensive but nonflammable halogenated hydrocarbons. Synthetic dry cleaning solvents; perchloroethylene and trichlorotrifluoroethane are currently considered for dry cleaning practices. Systems running on these synthetic solvents are called "perc" plants and fluorocarbon plants respectively.

4.2.7 Types of Machines[32]

There are two basic varieties of dry cleaning machines, transfer and dry-to-dry.

Transfer machines completes washing and drying process in separate machines. Washer extracts excess solvent from the clothes before they are transferred to the dryer, but some older version of petroleum plants have separate extractors for this purpose.

Dry-to-dry machines perform all of the operations in a single unit. All petroleum solvent plants comprises of transfer type machines, while synthetic solvent plants can be of either type of machine.

4.2.8 Dry Cleaning Industry [32-34]

This industry is further classified as three sectors: coined operated, commercial operations, and industrial cleaners.

Coined operated shops are usually part of a dry cleaning "self-service" site for consumers. In such facilities only synthetic solvents are used in for dry cleaning machines. Such machines are small, with a capacity of 3.6 to 11.5 kg (8 to 25 lb) of clothing.

Commercial operations, such as small neighborhood or franchise dry cleaning shops. Generally use perchloroethylene and petroleum solvents for their dry cleaning plants. A typical "perc" plant operates a 14 to 27 kg (30 to 60 lb) capacity washer/extractor and an equivalent size reclaiming dryer.

Industrial cleaners have relatively larger dry cleaning plants which supply rental service to businesses or industries for products such as uniforms, mats, mops etc. Approximately 50 percent of the dry cleaning industries use perchloroethylene as solvent. A typical large industrial cleaner has a 230 kg (500 lb) capacity washer/extractor and 3 to 6 38-kg (100-lb) capacity dryers.

4.3 Dry Cleaning Solvent[35]

Historically, different chemicals have been subjected to dry-cleaning purposes. These chemical include: camphor oil, turpentine spirits, benzene, kerosene, white gasoline, petroleum solvents (primarily petroleum naphtha blends), chloroform, carbon tetrachloride, perchloroethylene, trichloroethylene, 1,1,2-trichlorotrifluoroethane, glycol ethers, 1,1,1-trichloroethane, n-propyl bromide and liquid carbon dioxide.

Currently, the focus of the research will be on the solvents used by the facility under observation. For the purpose of conciseness only two solvents will be discussed, the old / previously used solvent perchloroethylene and present solvent mineral turpentine oil (MTT).

4.3.1 Perchloroethylene (PCE)

PCE was the previous solvent used by the facility. In industries, PCE is manufactured in form of four different grades: dry-cleaning grade, vapor degreasing grade for metal degreasing, technical grade for the manufacture of other chemicals and high purity grade used for extraction. Material Safety Data Sheets (MSDS) for dry cleaning-grade PCE shows that it has a purity ranging from 99% to 99.9%. Some of the common impurities are: 1,1,1-trichloroethane, carbon tetrachloride, dichloromethane, trichloroethylene, water and other chlorinated solvents.

PCE is a highly oxidized compound and has been known as the most stable among chlorinated solvents. But it degrades in the presence of light, heat and oxygen to produce trichloroacetyl chloride and tetrachloroethylene oxide. Moreover, hydrochloric acid is produced if water is present. To tackle this issue, manufacturers add stabilizers to PCE. These stabilizers function as oxidation inhibitors and acid acceptors to neutralizing the acidic components present in PCE. See table 4-2 and 4-6 for more information and properties.

Table 4-2 : Physio-chemical Properties [36]

Property	Value
Melting point	-22.0 to –22.7°C
Boiling point	121.2°C
Relative density	1.623 at 20°C
Vapor pressure	1.9 kPa at 20°C
Water solubility	~149 mg/l at 20°C
Flammability	No flash point, experimental conditions.
Explosive properties	Not explosive.
Oxidizing properties	Can oxidize in presence of air and light. Not considered as an oxidizing agent.
Solubility in other solvents	Miscible with alcohol, ether, chloroform and benzene

At the end of twentieth century, the United States Environmental Protection Agency (U.S. EPA.) proposed national emission standards to limit emissions from dry-cleaning plants. Many drycleaners switched transfer machines with dry-to-dry machines and improvements in the design of these machines that resulted in reduced PCE emissions and higher solvent mileage, the amount of fabric cleaned per unit of solvent. In 1996, the dry-cleaning industry was still the largest user of PCE in the U.S, same year EPA issued National Emission Standard Hazardous Air Pollutants (NESHAP) Requirements which obligated PCE drycleaners to monitor emissions and keep maintenance records of their machines. In 2006, the California Air Resources Board voted to phase out PCE dry-cleaning by 2023. Under the final rule of National Perchloroethylene Air Emission Standards for Dry Cleaning Facilities, after July 27, 2008

transfer machines could no longer be used in PCE dry-cleaning plants. These actions have brought reduction in the quantity of PCE used by drycleaners and stimulated the use of substitute dry-cleaning solvents.

4.3.2 Mineral Turpentine Oil

Mineral Turpentine oil (MTT) is a petroleum solvent also commonly known as mineral sprit; white sprits; Stoddard solvent (MSDS name). Attock Refinery Limited (ARL) Pakistan is one of the manufacturer, specifications of MTT is given in table 4-3 [37]. The brief description of tests used for determining the properties of MTT are given in the upcoming heading. These tests are taken as reference from American Society of Testing and Materials (ASTM)

Table 4-3 : MTT specification

Test Description		Test Method ASTM/IP	Results/ Values	Units	Max/ Min
Color		D-156	+21	----	Min
Flash Point		D-56/ IP 170	35	^{o}C	Min
Copper strip correction at 50^{o}C (122^{o}F)		D-130	1		Max
Distillation		D-86			
	50% Vol. Rec.		176	^{o}C	Max
	Final Boiling Point		215	^{o}C	Max
	Residue		1.5	Vol.%	Max
Aromatic Constants		D-1319	25	Vol.%	Max
Strong Acid Number		D-974	NIL	Mg KOH/gm	Max
Dr. Test		D4952	Negative	---	---

Courtesy of ARL[37]

4.3.3 Test Methods

The test methods used for determining specifications of MTT are internationally recognized and are standardized by ASTM and comes under international precision (IP) for determining test method precision.

4.3.3.1 ASTM D-156 Color Test

It is visual testing for the color of a wide variety of petroleum products, such as lubricating oils, heating oils, diesel fuel oils, and petroleum waxes. Used mainly for manufacturing control purposes, an important quality characteristic, since color is readily observed by the user of the product. In some cases, the color may serve as an indication of the degree of refinement of the material. Using a standard light source, a liquid sample is placed in the test container and compared with colored glass disks ranging in value from 0.5 to 8.0. When an exact match is not found and the sample color falls between two standard colors, the

higher of the two colors is reported. Sometimes a diluent, a Solvent having a color lighter than +21 Saybolt color by test method D156, is used for diluting dark samples for the test, such as kerosene, white oil or solvent neutral 100 of satisfactory purity that meet the color requirements for +21 Saybolt color test are also acceptable[38].

4.3.3.2 ASTM D-56, Flash Point Test

This test fallows the specifications comes under IP 170 as per international standards. Flash point measures the tendency of the specimen to form a flammable mixture with air under controlled laboratory conditions. This test method covers the determination of the flash point, by tag manual and automated closed testers, of liquids with a viscosity below 5.5 mm^2/s (cSt) at 40 °C (104 °F), or below 9.5 mm^2/s (cSt) at 25 °C (77 °F), and a flash point below 93 °C (200 °F). If a liquid has a tendency to form a surface film under test conditions or containing suspended solids, test method D93 can be used[39].

The automated Tag Closed Cup flash point tester ensures the accuracy and precision required according to the ASTM D56 and related test methods. The test sample is heated at a prescribed rate of temperature increase throughout the standard temperature test range to 100°C. The flash point tests are simply conducted by mounting the flash cup filled with sample into the test position and selecting a pre-programmed test method or the search mode to determine an approximate flash point. The automation routines provide accurate test results. Ignition by gas flame or electrical ignitor is included, along with safety cut-off devices. The measurement range can be extended to –30°C by any appropriate external chiller[40].

4.3.3.3 ASTM D-130, Copper Strip Test

This test method covers the determination of the corrosiveness to copper of aviation gasoline, aviation turbine fuel, automotive gasoline, cleaners (Stoddard) solvent, kerosene, diesel fuel, distillate fuel oil, lubricating oil, and natural gasoline or other hydrocarbons having a vapor pressure no greater than 124 kPa (18 psi) at 37.8°C. A polished copper strip is immersed in a specific volume of the sample being tested and heated under conditions of temperature and time that are specific to the class of material being tested. At the end of the heating period, the copper strip is removed, washed and the color and tarnish level assessed against the ASTM Copper Strip Corrosion Standard. Some products, may have a much higher vapor pressure, normally a characteristic of automotive or aviation gasolines. For this reason, exercise extreme caution to ensure that the pressure vessel used in this test method is not placed in the 100°C (212°F) bath. Samples having vapor pressures in excess of 124 kPa (18 psi) may develop sufficient pressures at 100°C to rupture the pressure vessel. For any sample having a vapor pressure above 124 kPa (18 psi), a different test method D1838 is used[41].

4.3.3.4 ASTM D-86, Test Method for Distillation

This test method covers the atmospheric distillation of petroleum products and liquid fuels using a laboratory batch distillation unit to determine quantitatively the boiling range characteristics of such products as light and middle distillates, automotive spark-ignition engine fuels with or without oxygenates, aviation gasolines, aviation turbine fuels, diesel fuels, biodiesel blends up to 20 %, marine fuels, special petroleum spirits, naphtha, white spirits, kerosene, and Grades 1 and 2 burner fuels. It is not applicable to products containing appreciable quantities of residual material. A 100-mL specimen of the sample is distilled under prescribed conditions for the group in which the sample falls. A laboratory batch distillation unit is used at ambient pressure under conditions that are designed to provide approximately one theoretical plate fractionation. Systematic observations of temperature readings and volumes of condensate are made, depending on the needs of the user of the data. The volume of the residue and the losses are also recorded[42].

4.3.3.5 ASTM D-1319, Fluorescent Indicator Adsorption

This test method is for determining hydrocarbon types over the concentration ranges from 5 to 99 volume % aromatics, 0.3 to 55 volume % olefins, and 1 to 95 volume % saturates in petroleum fractions that distill below 315°C. This test method may apply to concentrations outside these ranges, but the precision has not been determined. Samples containing dark-colored components that interfere in reading the chromatographic bands cannot be analyzed. About 0.75 mL of sample is introduced into a special glass adsorption column packed with activated silica gel, contains a mixture of fluorescent dyes in a small layer. When all the sample has been adsorbed on the gel, alcohol is added to desorb the sample down the column. The hydrocarbons are separated according to their adsorption affinities into aromatics, olefins, and saturates. The fluorescent dyes are also separated selectively, with the hydrocarbon types, and make the boundaries of the aromatic, olefin, and saturate zones visible under ultraviolet light. The volume percentage of each hydrocarbon type is calculated from the length of each zone in the column[43].

4.3.3.6 ASTM D-974, Test Method for Acid and Base Number by Color-Indicator Titration[44]

This test method covers the determination of acidic or basic constituents in petroleum products and lubricants soluble or nearly soluble in mixtures of toluene and isopropyl alcohol. It is applicable for the determination of acids or bases whose dissociation constants in water are larger than 10^{-9}, extremely weak acids or bases whose dissociation constants are smaller than 10^{-9} do not affect. Salts react if their hydrolysis constants are larger than 10^{-9}.

A sample is dissolved in a mixture of toluene and isopropyl alcohol containing a small amount of water and the resulting solution is titrated at room temperature with standard alcoholic base or alcoholic acid solution, respectively, to the end point indicated by the color change of the added p-naphtholbenzein solution (orange in acid and green-brown in base). To determine the strong acid number, a separate portion of the sample is extracted with hot water and the aqueous extract is titrated with potassium hydroxide solution, using methyl orange as an indicator.

4.3.3.7 ASTM D-4952, Doctor Test

This test method is intended primarily for the detection of mercaptans in motor fuel, kerosene, and similar petroleum products. Sulfur present as mercaptans or as hydrogen sulfide in distillate fuels and solvents can attack many metallic and non-metallic materials in fuel and other distribution systems. A negative result in the doctor test ensures that the concentration of these compounds is insufficient to cause such problems in normal use. For the test, a sample is shaken with sodium plumbite solution, a small quantity of powdered sulfur added, and the mixture shaken again. The presence of mercaptans or hydrogen sulfide or both is indicated by discoloration of the sulfur floating at the oil-water interface or by discoloration of either of the phases[45].

4.4 Emissions and Controls on Emissions

The dry cleaning solvent itself is the primary emission. Since the cost of petroleum solvents is low and because of fire hazards associated with vapors, petroleum plants generally lack solvent recovery unit. However, some emission control can be achieved by maintaining all equipment and using good operating practices such as not overloading machinery. Contrarily, fluorocarbon plants are consist of the dry-to-dry machines to conserve solvent vapor and all are closed systems with solvent recovery units. However, high emissions can still take place because of poor maintenance and operation of the plant.

4.4.1 Emission Factors for Dry Cleaning Operations

Table 4-4 shows the emission factors associated with dry cleaning operations. For estimates over large areas, these factors may be applied for coin-operated and commercial dry cleaning emissions. Indirectly Emissions can also be calculated by determining the amount of consumed solvent. In short, all input solvent is eventually lost to the atmosphere i.e. annual consumed solvent per annual weight of clothes serviced.

4.4.2 Types of Controls on Emission

Solvent emission controls for dry-cleaning plants are mostly developed out of economic necessity. For expensive solvents like perchloroethylene, it is cost effective to control and recover the solvent as much as possible. For petroleum solvents, controls systems are leaner and relatively less stringent as control systems can end up much expensive then the solvent saved by the system itself. Following are the potential and applied control measures:

1. Carbon Absorption
2. Housekeeping
3. Incineration
4. Process Changes
5. Refrigeration Condensation
6. Waste solvent treatment

Table 4-4 : Emission Factors

Solvent	**Sources of Emission**	**Calculation kg/100kg (lb/100lb)[1]**	
		Typical System	**Controlled System**
Petroleum (transfer type process)	Washer/dryer[2]	18	2[3]
	Uncooked (drained)	8	----
	Centrifuged	----	0.5-1
	Still disposal residue	1	0.5-1
	Miscellaneous	1	1
PCE (transfer type process)	Washer/dryer/still/ muck cooker	8	0.3
	Uncooked muck	14	----
	Cooked muck	1.3	0.5-1.3
	Centrifuged filter	1.1	0.5-1.1
	Still disposal residue	1.6	0.5-1.6
	Miscellaneous[4]	1.5	1
Possible Causes of Excess Solvent Consumption/Loss (Miscellaneous)			
Loose bungs on storage containers		Lint between basket and shell of dryer	
Loose pipe fittings		Water separator malfunctioning	
Bad gaskets		Machine over loading	
Clogged lint filter		Leakage in air vents	
Lint build-up in condenser		Faulty absorber operation	
Lint on fan blades		Overdue absorber filters	
Poor extraction cycle of a washer		During transfer of load to dryer from washer	

[1] References [28-29]
[2] In wash different amount of solvent is retained by different materials (synthetics, 10kg/100 kg; cotton, 20 kg/100 kg; leather, 40 kg/100 kg).
[3] Emissions from washer, dryer, still, and muck cooker are passed collectively through a carbon absorber.
[4] Miscellaneous sources include fugitives from flanges, pumps, pipes and storage tanks, and fixed losses such as opening and closing dryers etc.

4.4.2.1 Carbon Absorption

Absorption is the property of a surface to retain molecules of a fluid which have come in contact with the surface, there are two types of absorption physical and chemisorption, only the former type is considered in present context. Extend of absorption depends upon the gas/surface combination, temperature, pressure and surface are of absorber. Solvent vapors can be collected at low temperature (~100°F) and desorbed later in a concentrated form at a low temperature[27]. PCE can be retained on the carbon very easily.

Activated carbon is used in many applications for the removal of organic compounds from carrier gases (like air) by absorption. It has been extensively used to recover PCE plants. Earlier plants use water cooled or refrigerated condensers to control 88-90% losses but rising cost of solvent made absorption of remaining 10-15% attractive and feasible. Carbon absorption usually applied at end of the dryer process, (deodorizing) fresh air is drawn in and vented to the absorber, before that recirculating air from dryer exhaust is chilled in condenser, as initially concentration of solvent is high. The working bed capacity ($weigh\ of\ solvent \div weigh\ of\ carbon$) for PCE is round about 20% [28].

4.4.2.2 Housekeeping

The losses associated with poor maintenance of equipment are difficult to quantify but left unchecked is certainly causing efficiency of consumption per unit weight of load. Housekeeping is something that is dependent upon the operator or maintenance department. In table 4-3, the under section possible causes of solvent loss, different factor are identified, overcoming these point losses can result in significant saving of solvent[28]. Record keeping of consumed solvent and load processed is one way of finding out the effects of good housekeeping. In short one way of defining housekeeping is to reduce systematic errors by maintenance and human error by defining and regulating the standard operating procedures (SOPs) related to the equipment handling and human safety.

4.4.2.3 Incinerator

Incinerator is a device that burns exhaust gases (having solvent vapors) on the expense of fuel. From a strictly environmental and technological point, incineration is a feasible control measure but the high exhaust volume flow from petroleum dryers and current cost of fuel severely handicap its use in the dry cleaning plants. Two type of incineration is applicable:

- Separate Incinerator: high volume flow would require a large quantity of fuel for proper burn out of the solvent vapors.
- Boiler Incineration: small boilers in industrial laundries cannot handle high exhaust volume from typical petroleum dryer.

4.4.2.4 Process Changes

These kind of control measure can be only possible by embracing new technologies and move effective equipment. Additionally, for process changes considerable research and development of new equipment in different areas is required such as, filter muck cooking, improved distillation, improved liquid and vapor seals and reclaiming type dryers for petroleum solvents. Table 4-4 shows different emission factors that can be researched and improved.

4.4.2.5 Refrigeration Condensation

During the process of drying, hot air (from electric heaters/heat exchanger) is forced by blower, circulate in the dryer, this hot air caries away the solvent from the clothes and passes through a condenser which usually operates on water circulating in the pipes of the condenser. The efficiency of simple condenser is low and depend upon the temperature of circulating water, to increase the efficiency refrigeration condensation can be used which increases the efficiency and at the same time can handle high exhaust volume since it requires less time for exhaust air to remain in contact with the condenser surface.

4.4.2.6 Waste Solvent Treatment

Waste from the washer/extractor and dryer can be used for recovering solvent. In many PCE plants solvent in cooked out of filter waste materials. Well controlled plants can potentially reduce this emission source by direct and indirect steam distillation. Other options for disposal include recovery off site by a solvent disposal vendor and cartridge filtration. Solvent losses from distillation bottom disposal can be reduced in oil cookers (similar to muck cookers) to levels well below 1kg/100kg of load serviced [28].

4.5 Material Safety Data Sheet (MSDS) for Solvents

A material safety data sheet (MSDS) is a document prepared by the manufacturer of the product to provide information to the end-user of the product. There are usually sixteen section mention in a MSDS of a material. Table 4-5 enlist the section mention in a MSDS [46].

Table 4-5 : Sections of a MSDS

Sections of a Material Safety Data Sheet [40]	
1. Chemical Product and Company Identification	2. Composition and Information on Ingredients
3. Hazards Identification	4. First Aid Measures
5. Fire and Explosion Data	6. Accidental Release Measures
7. Handling and Storage	8. Exposure Controls/Personal Protection
9. Physical and Chemical Properties	10. Stability and Reactivity Data
11. Toxicological Information	12. Ecological Information
13. Disposal Considerations	14. Transport Information
15. Other Regulatory Information and Pictograms	16. Other Information

For the purpose of this portion of the dissertation, the solvents MSDS will be used for collecting critical information on safety, hazards, handling, storing, accidental measures, ecological and disposal measures. Different MSDSs were reviewed which were provided by different manufacturers. It was found that Chemical Abstracts Service (CAS) registry number was same, but the manufacturers has different recommendations regarding its uses, moreover the are series of materials which have different CAS numbers but the all have a single common name with different uses, the reason was the difference in the percentage of different compounds that constitute the material. Consequently, it was difficult to select the CAS number of the material which exactly comply with the solvent characteristics under consideration. With the help of comparison on the grounds of physical and chemical properties of the solvents and most common use of the material as a solvent for dry cleaning purposes, it was found the CAS numbers 127-18-4 and 64742-82-1 closely fulfil the description of PCE and MTT oil respectively. The table 4-6 contain the safety data sheet for both solvents, which have been congregated from multiple sources.

Table 4-6 : Safety Data Sheet for Dry Cleaning Solvents

Generic		Dry Cleaning Solvents	
		Perchloroethylene (PCE)[47-49]	**Mineral Turpentine Oil[50-52]**
CAS Registry No.		127-18-4	64742-82-1
Synonym		Tetrachloroethylene; Perclene; Tetraleno; 1,1,2,2-Tetrachloroethylene; Ethylene; Ethylene tetrachloride	Naphtha (petroleum), Petroleum Spirit, White spirit type 1, hydrodesulphurized heavy.
HAZARDS IDENTIFICATION			
Acute Health Effects	**Skin**	May cause severe irritation. Excessive drying or burns from repeated/prolonged contact.	Causes skin irritation, may cause skin redness, dryness or cracking.
	Ingestion	May cause central nervous system (CNS) depression; damage to kidney, liver. Possible symptoms: headache, excitement, fatigue, nausea, vomiting, stupor and coma	If swallowed may cause lung damage.
	Inhalation	Causes respiratory tract irritation, may cause CNS effects: vertigo, anxiety, depression, muscle incoordination and emotional instability.	May cause irritation of nose and throat, reduce sense of taste, nausea, loss of appetite, headache, drowsiness, dizziness and fatigue.
	Eyes	Transient irritation on contact, redness and pain, vapors cause irritation	Irritation of eyes, does not injure eye tissue
Chronic Health Effects	**Skin**	May cause defatting and dermatitis	
	Ingestion / inhalation	May cause: nervous system effects including muscle tremors and incoordination; liver and kidney damage; reproductive and fetal effects	memory impairment, forgetfulness, excessive fatigue, irritability, weariness, inability to concentrate, low frustration tolerance, headache, dizziness, apathy, lack of initiative, anxiety, nervousness, depressions, bursts of perspiration, alcohol intolerance, abdominal pains, diarrhea, nausea, impotence, reduced libido, blurred vision.
	Eyes	Debatable on causing subtle deficits to vision	
	Carcinogenic (Classified group)	Proven for animals (A3 by ACGIH). Probably for humans (A2 by IARC). Measurable risk not found if handled as recommended	Increased relative risks for certain cancers (e.g., lung, kidney, prostate, Hodgkin's lymphoma) have been observed.
Other Chronic Effects	**Mutagenic effects**	Mutagenic for bacteria or yea	Not mutagenic for bacteria or yea
	Teratogenic Effects	Not available	Not expected to impair fertility.
	Developmental toxicity	Not available	Not available
FIRST AID MEASURES			
Eyes		Remove, if contact-lenses. Immediately flush eyes with plenty of water for at least 15 minutes. Get medical attention if irritation occurs.	
Skin		Immediately flush skin with plenty of water. Cover the irritated skin with an emollient. Remove contaminated clothing and shoes, wash thoroughly before reuse. In case of serious	

	contact wash with a disinfectant soap and cover the contaminated skin with an anti-bacterial cream. Get medical attention.
Ingestion	Do NOT induce vomiting unless directed to do so by medical personnel. Never give anything by mouth to an unconscious person. Loosen tight clothing e.g. collar, tie, belt or waistband. Get medical attention if symptoms appear. If vomiting occurs, keep head low so that stomach content doesn't get into the lungs. Immediately rinse mouth and drink plenty of water (200-300 ml). Provide rest, warmth and fresh air.
Inhalation	If inhaled, remove to fresh air. In case of serious inhalation, evacuate the victim to a safe area as soon as possible. Loosen tight clothing such as a collar, tie, belt or waistband. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention if symptoms appear.
Notes to Physician: Treat symptomatically and Supportively	

FIRE FIGHTING MEASURES		
General Information	In any fire, wear a self-contained breathing apparatus MSHA/NIOSH (approved or equivalent), and full protective gear. Use water spray to keep fire-exposed containers cool.	
Extinguishing Media	Substance is noncombustible. Use media most suitable for surrounding fire.	Foam, water spray or fog, dry chemical powder or carbon dioxide. Do not use water in a jet.
Specific Hazards	Not combustible, but in a fire, decomposes to produce hydrogen chloride.	Vapors are heavier than air and may travel along the floor and in the bottom of containers, may be ignited by a spark, a hot surface or an ember

NFPA Rating	**Health hazard**	2 – Hazardous	1	Refer to **Appendix C** for the guidance of NFPA and HMIS rating Information.
	Fire hazard	0 – Will not burn	2	
	Instability	0 – Stable	0	
	Special hazard	None	None	
HMIS Rating	**Health**	2 – Moderate Hazard	2	
	Flammability	0 – Minimal Hazard	2	
	Reactivity	0 – Minimal Hazard	0	
	Personal protection	G – Glasses, Gloves, Breather mask	H – Glasses, Gloves, Suit, Mask	

ACCIDENTAL RELEASE MEASURES		
General Information	Use proper personal protective equipment as directed in section "personal protection"	
Spills/Leaks	Absorb spill with inert material (vermiculite, sand or earth etc.), then place in suitable container. Clean up spills immediately, observing precautions for personal protection. Provide ventilation. Prevent this chemical entering the environment. Keep its level below TLV, Check TLV on the MSDS and with local authorities.	Remove all heat or ignition sources. Avoid contact with skin and eyes. Do not breathe vapor. Ventilate area of leak or spill thoroughly. Evacuate the area of all non-essential personnel. Shut off leaks, if possible and without personal risk. Absorb with inert, damp, non-combustible material. Do not flush away residues with water.

HANDELING AND STORAGE		
Handling	Do not ingest/breathe gas/fumes/vapor/spray. Avoid skin contact. Wear protective clothing. If insufficient ventilation, wear suitable respiratory equipment. If ingested, seek medical advice immediately and show the container or the label. Keep away from incompatibles. Wash thoroughly after handling. Remove contaminated clothing and wash before reuse. Use only in a chemical fume hood. Avoid reusing used-containers.	Flammable product. Avoid breathing vapors, contact with skin, eyes and clothing. Handle and open containers with care in a well-ventilated area. Ensure that the workplace is ventilated, keep its level below TLV. Wash thoroughly after handling. No eating, drinking or smoking in contaminated areas. Ensure electrical continuity by grounding all equipment. Flame proof equipment necessary.

Storage	Keep away from heat and flame. Keep container tightly closed. In a cool, well-ventilated area.	
	Do not store in aluminum containers.	Outside or detached storage is preferred. Separate from oxidizing materials, smoking areas. Empty containers may be hazardous, retain product residues vapors and liquid.
EXPOSURE CONTROLS		
Engineering Controls	Provide exhaust ventilation or other engineering controls to keep the airborne concentrations of vapors below their respective threshold limit value.	
Exposure Limits	100 (ppm) from ACGIH (TLV) 150 (ppm) IDLH from NIOSH	Time Weighted Average (TWA): 8h TLC: 350 mg/m^3
PERSONAL PROTECTION		
Eyes	Wear chemical splash goggles	Wear approved safety goggles.
Skin	Wear appropriate protective gloves	Neoprene gloves are recommended.
Clothing	Wear appropriate protective clothing	Wear rubber apron, rubber footwear.
Respirators	In case of warrant respirator, use protection standards OSHA's 29 CFR 1910.134 [53] and ANSI Z88.2 [54] requirements or European Standard EN 149 [55]	If ventilation is insufficient, suitable respiratory protection must be provided.
STABILITY AND REACTIVITY		
Stability	Stable at normal conditions for use and storage	
Incompatibility	Oxidized by strong oxidizing agents. Incompatible with sodium hydroxide, finely divided or powdered metals such as zinc, aluminum, magnesium, potassium, chemically active metals such as lithium, beryllium, barium.	With strong oxidizing agents.
Avoid Conditions	Incompatible materials, ultra-violet light, open flame, direct sunlight, excess heat, temperatures above 150°C.	Avoid excessive heat, flames, other sources of ignition, contact with acids and oxidizing substances.
Hazardous Decomposition Products	Hydrogen chloride, chlorine, phosgene, carbon monoxide, carbon dioxide.	Oxides of Carbon and other organic compounds.
Special Remarks	Slowly corrodes aluminum, iron, and zinc.	Readily biodegradable. Oxidizes by photo-chemical reactions in air.
Polymerization	Will not occur.	Not available
ECOLOGICAL INFORMATION		
Routes of Entry	Through skin. Eye contact. Inhalation. Ingestion.	
Eco-toxicity	Fish: Fathead Minnow: LC50: 6.8 mg/l; 96 h Fish: Sheep head minnow: LC50 8.8mg/l; 96h Daphnia: Daphnia: EC50: 7,5mg/l; 48h Rat: Acute oral toxicity; LD50: 2629 mg/kg Rabbit: Acute dermal toxicity; LD50; >3228mg/kg Mouse: Acute vapor toxicity; LC50;5200; 4 h	Rat: Oral, LD50: 5,000 mg/kg Rat: Inhalation,LD50: 1,369 ppm /8h Rabbit: Skin, LD50: 3,160 mg/kg Eye/Skin irritation: Slight irritant Expected to be harmful: Fish/Aquatic invertebrate/Algae/Microorganisms: 10 < LC/EC/IC50 ≤ 100mg/l
Environmental	Evaporate in soil and water. In air, vapors expected	May accumulate in soil and water systems. Insoluble and will spread on water surface

DISPOSAL CONSIDERARIONS	
Waste Disposal	Must be disposed of in accordance with federal, state and local environmental control regulations
Other	Do not empty in drain

4.6 Standards on Water Effluence[56]

The case study has be conducted in Punjab the province of Pakistan. Table 4-7 shows the concerning standards for municipal and liquid industry effluents defined by the Punjab Environmental Quality Standards (PEQS). Effluents are in unit of **mg/l**, unless specified.

4.6.1 Other measures to be observed as per PEQS

1. Minimum dilution should be 1:10 on discharge, meaning for each 1 m^3 of effluent water, the recipient water body must have 10 m^3 of water for dilution.
2. Dilution is prohibited through fresh water mixing with the effluent before discharging.
3. Surfactant should be biodegradable.
4. Pesticides also include herbicides, fungicides and insecticides.
5. Sewage treatment plant achieves 80mg/l of BOD, value for industry is 200mg/l.
6. The pollutants in the intake/influent water are to be subtracted from the effluents to meet the PEQS limits.
7. The limit for temperature difference by effluent is 30°C at the zone edge where initial mixing and dilution occurs (in receiving body). If zone not defined, 100 m from point of discharge.

Table 4-7 : Water Effluents Standards

Sr. #	Parameter	To Inland Waters	To Sewage System
1	Temperature / Temperature Increase	≤ 3°C	≤ 3°C
2	pH value	6 – 9	6 – 9
3	Biochemical Oxygen demand (BOD) at 20°C	80	250
4	Chemical Oxygen Demand (COD)	150	400
5	Total Suspended Solids (TSS)	200	400
6	Total Dissolved Solids (TDS)	3500	3500
7	Grease and oil	10	10
8	Phenolic Compounds (as phenol)	0.1	0.3
9	Chloride (as Cl^-)	1000	1000
10	Chlorine (Cl_2)	1.0	1.0
11	Fluoride (as F^-)	10	10
12	An-ionic Detergents	20	20
13	Sulfate (SO_4^{2-})	600	1000
14	Sulfide (S^{2-})	1.0	1.0
15	Ammonia (NH_3)	40	40
16	Pesticides	0.15	0.15
17	Iron (Fe)	8.0	8.0
18	Total Toxic Metals	2.0	2.0

4.7 Standards on Air Effluence

Punjab Environment Protection Department under the PEQS has defined limitation for air effluents in terms of standards for ambient Air and standards for industrial gaseous emissions. Both standards are discussed in successive fallowing headings.

4.7.1 Standards for Ambient Air[57]

The concerning standards related to ambient air are given in the table 4-8.

Table 4-8 : Ambient Air Emission Standards

Sr. no.	Pollutant		Concentration In Ambient Air (µg/m^3)	
			Annual Average[1]	**24 Hours[2]**
1	**Sulfur Dioxide (SO2)**		80	120
2	**Oxides of Nitrogen**	**(NO)**	40	40
		(NO2)	40	80
3	**Suspended Particulate Matter (SPM)**		360	500
4	**Respirable Particulate Matter (10 & 2.5 microns)**	**PM_{10}**	120	150
		$PM_{2.5}$	15	35
			1 hour emission: 15 µg/m^3	
5	**Carbon Monoxide (CO)**		8 hours: 5mg/m^3	1 hour: 10 mg/m^3
6	**Lead (Pb)**		1	1.5

4.7.2 Standards for Industrial Gaseous Emissions[58]

The industrial gaseous emissions and their limitations are listed in the table 4-9. The unit for standards is mg/Nm^3, unless otherwise specified. There are other conditions which are to be met alongside the standards for gaseous emissions.

1. The size of the particulate is 10 micron or more.
2. Standards are Based on 1% sulfur content in fuel, higher content will cause prorated standards
3. In respect of emissions of SO_2 and nitrogen oxides given in the table 4-9, the power plant operating on oil and coal as fuel shall be subjected to additional PEQS regarding SO_2 and NO_X.

[1] Annual average is arithmetic mean of minimum 104 measurements in a year taken twice a weak 24 hourly at uniform interval

[2] 24 hours/ 8 hours value should be met 98% of the year. 2% of the time may exceed, not on two successive days

Table 4-9 : Gaseous Emission Standards

No.	Parameters	Emission Source or detail		Standard
1	**Smoke**	Opacity of smoke limit		40% or 2 Ringlemann Scale
2	**Particulate matter**	Boilers and furnaces	Oil fired	300
			Coal fired	500
			Cement Kilns	300
	Grinding, crushing, clinker, cookers and related processes, metallurgical processes, converters			500
3	**Hydrogen Chloride: HCl**	Any		400
4	**Chlorine: Cl_2**	Any		150
5	**Hydrogen Fluoride: HF**	Any		150
6	**Hydrogen Sulphide: H_2S**	Any		10
7	**Sulphur Oxides**	Sulfuric/Sulfonic acid Plants		5000
		Other plants except oil/coal power plants		1700
8	**Carbon Monoxide: CO**	Any		800
9	**lead**			
10	**Nitrogen Oxides**	Nitric acid manufactures		3000
		Other plants except oil/coal power plants		
		Gas fired		400
		Oil fired		600
		Coal fired		1200

4.8 Conclusions

According to the size standards, the facility under study comes under NAICS Code 812320 dry-cleaning and laundry services with annual receipts much less than dollar 5.5 million and according to small business compliance policy, it has employees less than 100.

The facility under study is not dominant as on a national basis, even with branches in different cities, it hardly covers a whole city.

In the first chapter of this dissertation, it is mentioned that the case of dry cleaning and laundry which is under observation is a part of service proving sector, also the table 4-1 places it in service sector and as per non-manufacturer, defines it as a concern that did not manufactured the product it supplies.

Form the portion of the dry cleaning industry, the capacity of the dry cleaning machines is mention, it can be taken as a bench mark regardless of the solvent type because the dry cleaning machines used by the facility under study are mostly refurnished locally and modified to work with mineral turpentine oil, present solvent used by this facility.

The present case study reveals that its yearly consumption of solvent approximately reaches the value of 10,000 Lt, which gives an average of 833.3 Lt per month. Because of poor

record keeping of the dry cleaning load, it is difficult to make an average consumption per kg (weight) of load.

Besides hardware changes, good emission control can be achieved by maintaining all equipment in good condition and good operating practices.

Usually maintenance schedules and check sheet/list are mandatory for machines and equipment, it ensures durability, reliability and safety from equipment failure, hazards and accidents. Because of no record keeping of load, repairs and poor maintenance practices related to machines and equipment, a major loss of energy and consumables is inevitable.

In case to emergency such as first aid measures, first aid box and other required medical attention should be in close proximity. A quick response/mitigation system should be defined, implemented and regulated on periodic intervals.

Even with the MSDS present, precautions must be taken. Exact and proper MSDS must be required from the supplier of the Dry cleaning solvents.

Water and steam generator emissions are major factors subjected to PEQS, for case study.

CHAPTER 5: SIMULATION USING ARENA SIMULINK

5.1 Simulation

Simulation is a representation of a plan, assessment of changes, determining of critical factors, visualizing the effects of improvements and identify the weaknesses of a system, all in a virtual domain, just by using the data provided or collected related to a particular case and a simulation software package. In the past simulation was carried out by using mathematical model and going through tedious calculation by means of iterative methods. But with the modernizations, it has become easier to use a software for simulation and obtain results faster and with better precision, accuracy and less errors as compare to manual simulation techniques.

5.2 Assumptions for Simulation Purposes

In any simulation method it is critical to make sound and critical assumptions. Although it is difficult to choose design variables among others, but by focusing on a critical variable it becomes relatively clear to determine which variables are important, dependent and irrelevant for the simulation purposes. Some assumptions are made to make the model simple and reduce large fluctuations in the values of variables. However, overlooking / neglecting or not considering a variable or real system feature may give misleading results.

For the present case study, simulation has been performed to evaluate the effects of time controlling caused by two different cases: the automatic time controlled washing machines and manually operated washing machines. This particular section of the real system was considered because washing machines are the major energy consuming equipment on the facility which can employ some minor changes to reduce the energy consumption, operation time and cost of the whole washing process. The assumption made for the simulation are as following:

- Since the student version of software is available, simple and small model is built for the simulation.
- Only the Laundry, Washing (not Dry Cleaning) Machines were considered.
- Carpet, Blanket, curtains and any big item are considered as one unit/piece equivalent to a single piece. Company provided data was difficult to compile and exclude such item from the calculation of the total number of items.
- Two Cases were simulated: Case 1: Manually operated. Case 2: Controller operated
- Employees are considered Busy as long as the Machine is active.

- Three days Average number of products of seven Branches are considered in the average calculation of total number of products.
- The total average number of pieces are taken without separating the garments on the bases of type of cleaning method and their relative compatibility to be batched together with one another.
- To cater the effect of large items such as blanket and rugs on the energy consumption, one more batch is added in the simulation along with additional resource module.
- Items which are Re-cleaned are considered by adding additional batch in the form of a resource module.
- Observed values and Results are taken as average, showing an average over all consumption per batch per machine.
- Only time based Differences/Changes are observed during the Simulation.
- Average cost of electricity is deduced from the average total consumption of energy by the machines per day and is used for calculating monthly average consumption.
- Only the washing machines are considered for current simulations. Other machines like water extractor and dryer are not part of the simulation, since their time of operation is small and they are less in numbers as compare to washing machines.
- As the industry is faced with seasonal increase in load, assumptions made with regard to monthly bases calculations are still approximated and minimum values. Seasonal impact on energy consumptions is difficult to simulate because of not having records regarding loads over the course of different seasons / year.

5.3 Readings and Parameters Selected for Simulation

Readings such as average number of pieces from different branches, number of batches formed, average time values and parameters such as simulation time, cycle time and other settings are given in the table 5-1.

Table 5-1 : Readings and Parameters

READINGS				
Branch/Franchise Name	**Average 3 days booking in no. of pieces**			**Average value**
Chakala, Scheme Three	27	11	60	33
Blue Area, Islamabad	105	39	81	75
Commercial Market	131	58	95	95
Jam-ayah Masjid, Rawalpindi	40	36	30	35
F-10 Branch	108	113	110	110
Asghar Mall road branch	84	34	37	52
I-10/3, Islamabad	142	232	187	187
Approximate Total Number of Pieces				587
Batch Size of a Washing Machine				
Machine Type	**Average no. of pieces**		**No. of batches out of 587 pcs**	
Washer front loaded	150		4	
Belly washer, top loaded	200		3	
Average Batches for simulation				
Washer front loaded	150		3	
Belly washer	200		2	
For blankets and rugs	10 - 36 blankets		1	
PARAMETERS				
Delay Type: Triangular	Case 1	Min: 29, Most Likely:33, Max: 42		
Delay Type: Constant	Case 2	Fix value: 30 (26 for operation, 4 for add/removing Load)		
Parameter Name	**Values**			
Number of Replications	3 and 26 days			
Replication length	1 day			
Hours per Replication	24			
Total Average no. of Pieces	587			
Average Batch Size	Washer : 3, Belly Washer : 2 and big items : 1			

5.4 Results

The results from the two cases i.e. Case 1: Manually operated and Case 2: Controller operated see figure 5.1, are compiled and compared in the table 5-2.

Table 5-2 : Simulation Results

Module	**Case 1, Average time (day)**			**Case 2, Average time (day)**		
Resources	**Normal**	**Minimum**	**Maximum**	**Normal**	**Minimum**	**Maximum**
Machine 1	0.0237	0.0210	0.0264	0.02083	0.02083	0.02083
Machine 2	0.0243	0.0205	0.0286	0.02083	0.02083	0.02083
Machine 3	0.0244	0.0216	0.0281	0.02083	0.02083	0.02083
Machine 4	0.0238	0.0211	0.0268	0.02083	0.02083	0.02083
Machine 5	0.0245	0.0216	0.0278	0.02083	0.02083	0.02083
Machine 6	0.0245	0.0216	0.0285	0.02083	0.02083	0.02083
	Busy cost, average (unit consumed)			**Busy cost, average (unit consumed)**		
Machine 1	0.8442	0.8377	1.053	0.83	0.83	0.83
Machine 2	0.4850	0.4075	0.57	0.415	0.415	0.415
Machine 3	0.8137	0.7209	0.939	0.695	0.695	0.695
Machine 4	1.9070	1.6845	2.136	1.66	1.66	1.66
Machine 5	2.9254	2.5795	3.3216	2.49	2.49	2.49
Machine 6	3.9144	3.4517	4.5495	3.325	3.325	3.325

Comparison between Case 1 and Case 2		Case 1	Case 2	Total Average Difference
		Total average	Total average	
Overall Time consumed	Normal	0.1452	0.12498	0.02022
	Minimum	0.1274	0.12498	0.00242
	Maximum	0.1662	0.12498	0.04122
Overall Unit Consumed	Normal	10.8897	9.415	1.4747
	Minimum	9.6818	9.415	0.2668
	Maximum	12.5691	9.415	3.1541

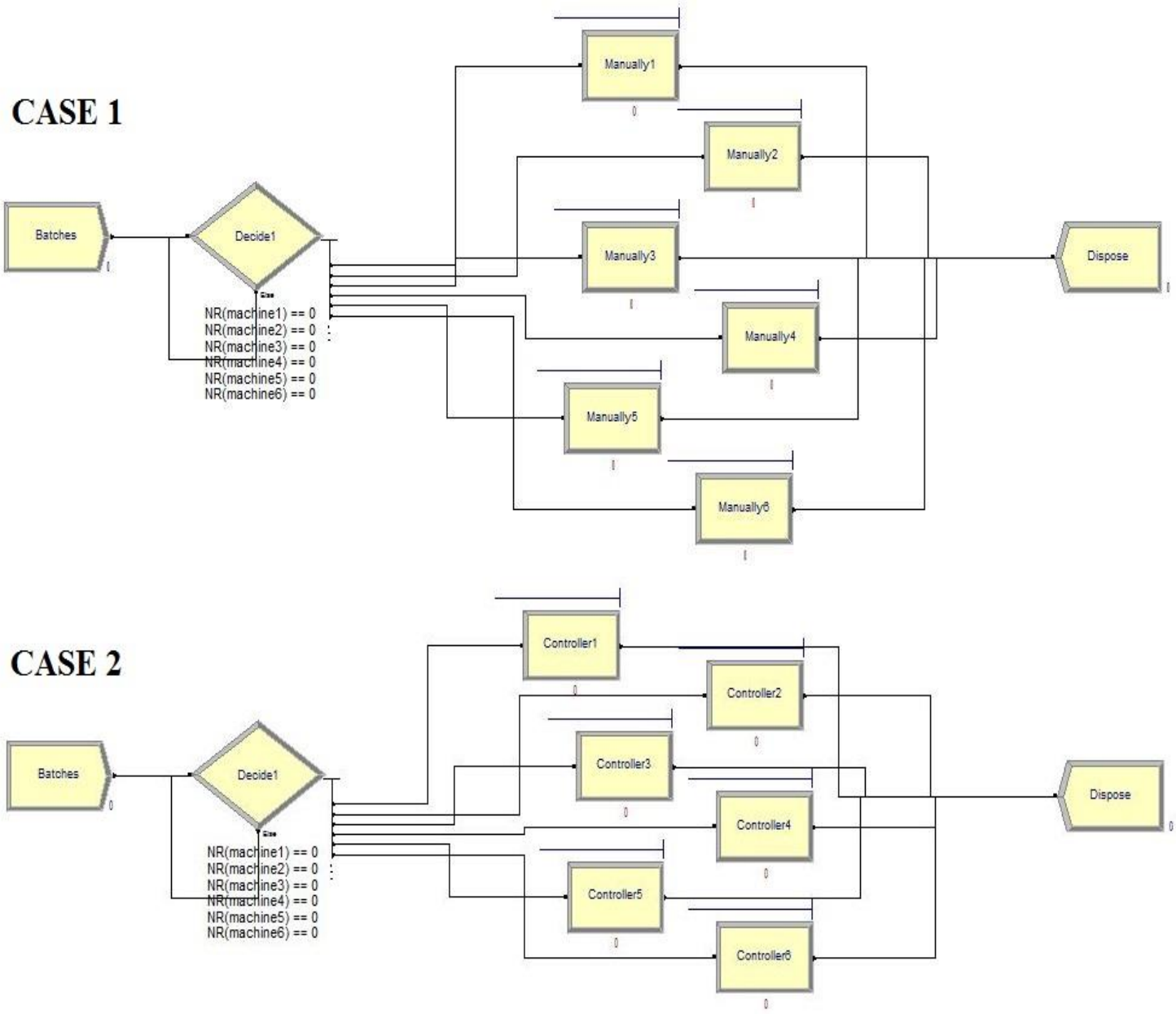


Figure 5.1 : Simulation Models Case 1 and Case 2

5.5 Findings and Conclusion

From the table 5-2, about 25 percent more time is utilized by the manually operated machines as compare to controller operated machines.

The overall unit consumption per day ranges from about 3 to 25 percent more, when machines are operated manually.

The simulation was run through 26 replications (working days in a month), about 8 to 95 units can be saved, lowering the energy consumption and electricity bill of the system.

Since the simulation results were average values, for the yearly based results, the maximum savings on electricity can reach up to 1140 units.

By applying automatic controller to other manually operated machines such as water extractors and dryers, the overall system energy consumption can be further reduced.

It must be kept in mind that for the calculation of individual machine energy consumption given in table 3-4, were taken using clamp multi meter, more accurate and actual results can be achieved through applying more sensitive instruments and using data from records of loading conditions over the time period of a year.

CHAPTER 6: FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

In this portion of the report the whole research is being summarized with respects to the aspects that are already discussed in the previous chapter. Here only the end results of the respective studied aspects will be gathered and represented in a single inclusive chapter, recommendations and future work will be proposed that covers up the whole case study.

Although, for the ease of the reader each chapter already contain its findings and conclusions, but for those who do not want to browse through those chapters, can easily read the following text, just for the purpose of knowing the results of the research work.

6.1 Conclusion from Literature Review

The size standards related to the case study are highlighted in the table 6-1. Since the industry being studied is in Pakistan, it stands in the category of medium enterprise (ME).

Table 6-1: Size Standard

State Bank of Pakistan (SBP)			
Enterprise Category	**No. of Employees**	**Annual Income (PRs)**	**Business Loans (PRs)**
Small Enterprise (SE)	50 Max	150 Million (Max)	25 Million (Max)
Trading Establishment Medium (ME)	0 - 100	150 - 800 Million	25 - 200 Million (Max)
Manufacturing/services Medium (ME)	**50 - 250**	**150 - 800 Million**	**25 - 200 Million (Max)**

Small Business Size Standard as per U.S. department of SBA			
NAICS Codes	**Industrial Description**	**Millions**	**No. Employee**
812310	Coin-Operated Laundries and Drycleaners	$ 7.5	-----
812320	**Dry-cleaning and Laundry Services (except Coin-Operated)**	**$ 5.5 (578.425 PRs)**	-----
812332	Industrial Launderers	$ 38.5	-----

The literature review uncovered different aspects that are relevant to case study and can be considered for implementation after appropriate measurement and modifications. However, because of fiscal and technological lacking, feasibility regarding experimentation and implementation is very low. Hence by keeping in mind the objectives of the research, it is not recommended to adopt such technologies and techniques which are currently not fiscally viable for the industry.

Meanwhile researches which are focused on; quality, environment protection, ergonomics, organizational work climate and competency of SMEs can be considered since they are more dependent upon the rules, regulations and managerial practices. Bringing changes in these industrial aspects can promise beneficial outcomes, but these changes are difficult to implement and maintain initially and their outcomes can take time to reach the level of tangibility and measurability.

6.2 Outcomes of Employee Level Analysis

Lack of professional education. Learning by doing concept (contrary to developed country).Multi-skill (experience of operating multiple machines or departments work) persons are present in all departments however their skill is on the bases of learning by doing. No professional Training.

More than 60 percent of the employees are under-matric, making it difficult to make them understand things logically and technically. A hindrance in Skill Development of employees. Those who have done matric or intermediate (and 0% Graduates), still lack professional education/diploma. Few who claim work experience before joining this industry, still lack Professional knowledge.

6.2.1 Employee Level Recommendations

Every now and then, a group demonstration/discussion of how to perform an activity most efficiently, friendly competitions between employees.

Defining SOPs, by taking their input, keeping in mind their work habits and level of understanding. Plan for implementing SOPs, add performance perks – something employees go for like monthly bonuses/rewards, employee of the month.

Check and balance system is also need, otherwise accounting the performance of a employee will be difficult.

6.3 Outcomes of Department Level Analysis

SOPs are hard and fast rules (documented form), in present case they are learned by seeing/ listening to another person performing/explaining an activity, supposed to memorize that by heart, understand and perform by himself afterwards

The work outline for a particular job is not found in descriptive form. Only a general undertaking/contract of being hired by the company is signed. Designation is assigned, after the work learning/training completes

Record of services is kept as an invoice backup, to tag the products to be serviced, also showing number of pieces. An overall evidence of transection of products. Information like

how many are sent to wash and how may to dry cleaning cannot be deduced. Cannot tell how many times did a same customer checked-in to buy cleaning services.

Presence/occurrence of Issues/Defects in high, more than 70 % work force approved of it. Records of issues, frequency of issues and reasons of those issues are not kept. Many product goes to Re-cleaning (RC), those records are not maintained.

Since one way or another, every employee (except accounts and workshop employees) comes in contact with any garments/textile product to perform any activity like booking (invoice making), washing, pressing, packing or handling. They (100%) claim to be responsible for quality checking, but 70% also approve of reoccurring issues in cleaning services.

6.3.1 Department Level Recommendations

Making Record of any problem is the basic tool for finding the causes, their relationship to the problem and effects of amendment/changes on the problem solving procedure. These problems have a direct effect on the customer, may end up in losing customers and eventually build up a bad reputation in the market. By defining short term goals/objectives to reduce and eradicate the root cause of these issues, will lead to good results.

SOPs do not just define how to perform, but how to perform safely, cost and time efficiently. SOPs helps in defining standards that automatically reduces the probability of defects reoccurrence. A long term, everlasting preventive measure.

The washing and dry cleaning department has the maximum consumption in compare to any other department, more than twice of any other. Hence any change in the utilization of energy in this department will significantly improve the consumption of the system.

Comparing the size and number of batches a small hydro-extractor can service to that of a large hydro-extractor at a given time period, can help us in deciding which extractor should be used under which conditions, since the large extractor approximately require more than three times the energy as that of the small extractor. Machines like washer plus extractor, performs both functions recommended, it is both time and cost efficient.

Some electrical load cannot be altered like that of the steam and iron pressing machines and equipment. There is very little gap for improvement under present situation. Slowly replacing the old equipment with the new and improved ones will definitely be more feasible with visible effects with regards to ergonomics, efficient and energy conservative.

6.4 Outcomes of System Level Analysis

The Industry was established more than three Decades ago and it has 10 outlets other than head office branch and factory in the twin cities Rawalpindi and Islamabad. Marketing practices are obsolete. Dependent upon its publicity attained over age and good will with customers. The only practices which are the same as those inbuilt in any business: Franchises/Branches, Monograms on its delivery vehicles, Monograms on its packing materials, Visiting cards on their outlets and Website as a formality (does not have any online booking or complaining option)

The table 6-2 shows the average monthly utilization of electricity, MDI and natural gas, while average daily water consumption is also given in the table.

Table 6-2 : Utilization of Energy and Resources

Utilities	Monthly or Daily Consumption
Electricity	Varies 3280 - 6240kWH, average 4760kWH
maximum demand indicator (MDI)	Ranges 36-47, average 40.67kW.
Natural Gas	variation 179.2 - 282.14 MBTUs, average 218.76MBTUs
Water	33300.61 liters, 2 × (66.6 m^3/day). Daily

All the machines and equipment were calculated for their electrical load. It was found the washing department has the highest value i.e. 56.67 kW about half the load of the whole industry which is 128.29 KW. Reduction in the washing department consumption of electricity will improve the whole system efficiency my many folds.

All the operations are manually operated, even the washing machines. Masterly are manually controlled, once the machine is switched on, it relies on the availability of the operator and at what time he will switch off the machine. During this time frame, if the machine runs more than its optimum time, it will consume energy which has not produced any work. Controlling it by means of a control mechanism (timer based) will eliminate the risk of over consumption of electricity and reduce the mental burden on the operator.

The capacity of machines being deduced through dimensional comparison with their respective type of machines does not specifies the type of garments to be serviced by those machines. However, the present facility fallows its own loading criteria which is based upon number of pieces of garments whose average mass in kg is given in table 3-6. To visualize the comparison a line graph is shown in the figure 3.5, mostly machines are loaded below the rated capacity however still few machines are loaded above rated load with significant difference between respective comparing loads.

6.4.1 System Level Recommendations

In a process flow, time is asset and it should be maintained for each activity to make sure continuous flow of process and time. Activities that can be made time efficient will reduce the time period of whole process and reduce consumptions of utilities, consumables and use of machinery and equipment.

Ergonomically it must be kept in mind that all the activities are manually done and operated by employees, their work load should not affect their performance as quality of the services performed on products is directly linked with the employees performance.

Area wise distribution of different department had gone through changes in the past. Over the time period of three decades, now the facility cannot meet the expense of going into major change on system level, however within the department changes can be done for effective area management or installation of any new equipment.

The number of product that comes in RC (re-cleaning) can be used as an indicator of the system performance. Less or minimum number of RC products will show improved performance otherwise it has gone worse as the number of RC products increases.

To understand the importance of quality, a simple flow chart showing relationship with different aspects is given in the figure 6.1.

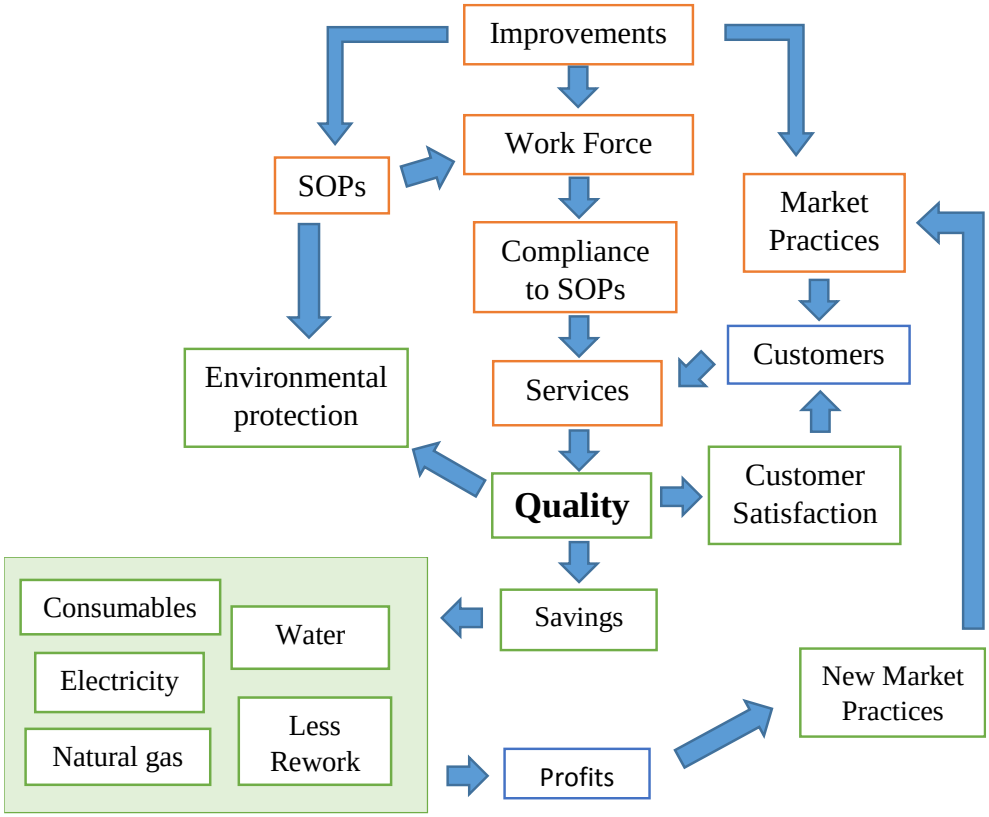


Figure 6.1 : Quality and its relationship

Among the strategies for implementing quality programs, given in appendix B, the employee involvement-based approach, The Customer-Driven Improvement Approach and the total quality systems approach can be practically implemented to the current system.

The type of garments which are loaded must be quantified as per their shape and form because garments like kameez/shirts and tea-shirts with full sleeves tends to tangle together because of their long sleeves, as a result the whole mass of garments swirl as a single mass at the bottom of the drum and separate pieces do not get proper mechanical tumble action which lead to uncleaned garments at the end of the washing process.

6.5 Outcome of Software Base Analysis

Simulation based analysis was conducted to determine the effects on the consumption of energy and time. From the table 5-2, about 25 percent more time is utilized by the manually operated machines as compare to controller operated machines. The overall unit consumption per day ranges from about 3 to 25 percent more, when machines are operated manually. The simulation was run through 26 replications (working days in a month), about 8 to 95 units can be saved, lowering the energy consumption and electricity bill of the system. Since the simulation results were average values, for the yearly based results, the maximum savings on electricity can reach up to 1140 units.

6.5.1 Simulation Related Recommendations

By applying automatic controller to other manually operated machines such as water extractors and dryers, the overall system energy consumption can be further reduced.

It must be kept in mind that for the calculation of individual machine energy consumption given in table 3-4, were taken using clamp multi meter, more accurate and actual results can be achieved through applying more sensitive instruments and using data from records of loading conditions over the time period of a year.

6.6 Future Work

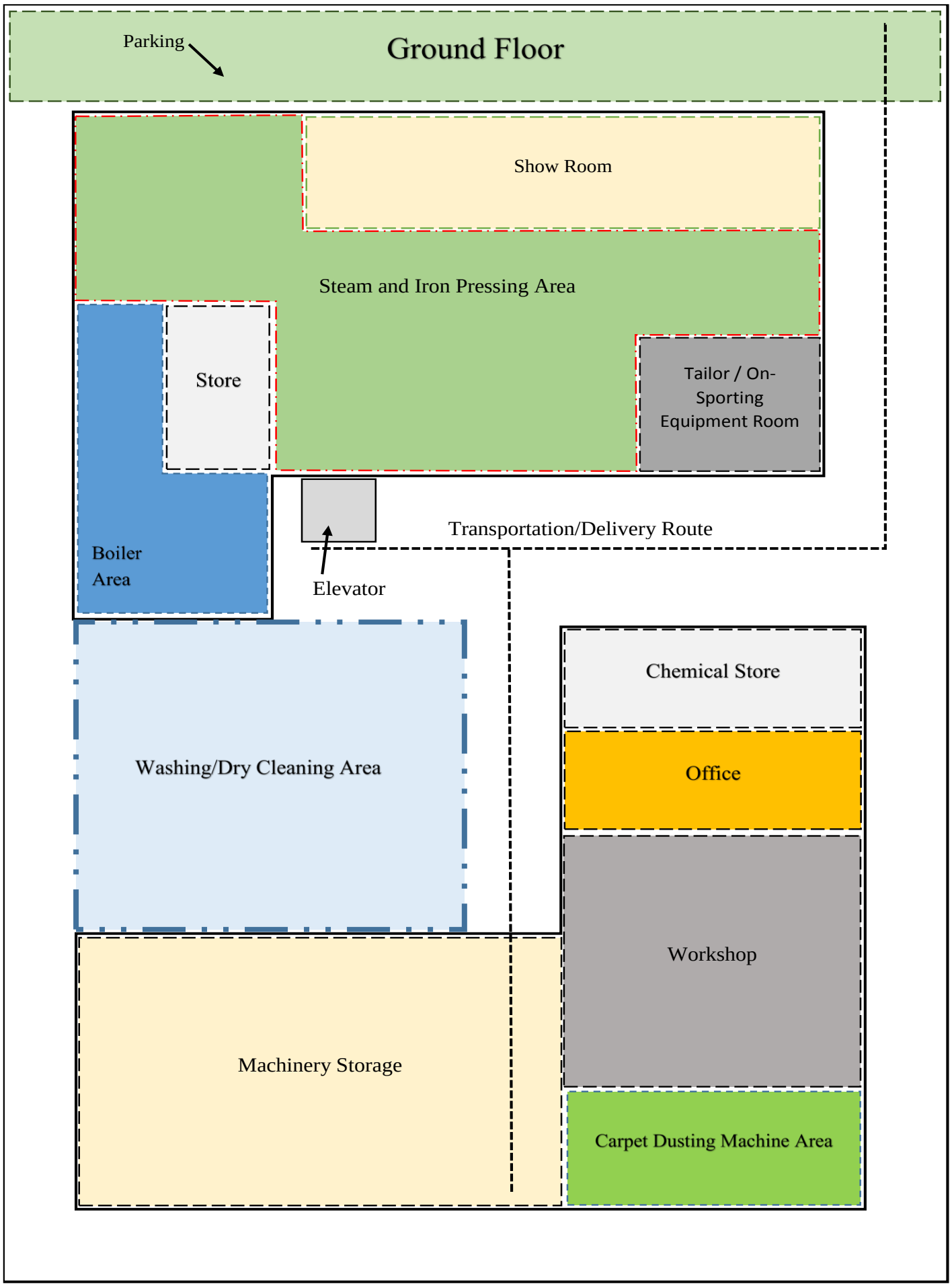
- Work on the different aspects related to the same industry, uncovered during the literature review.
- Once record maintenance system is implemented, more detailed simulation model can be created for the purpose of study and improvement in the system.
- Steam generator and steam flow system, used for steam pressing and other processes, is a domain of it's on which can be analyzed and worked upon.

APPENDIX A

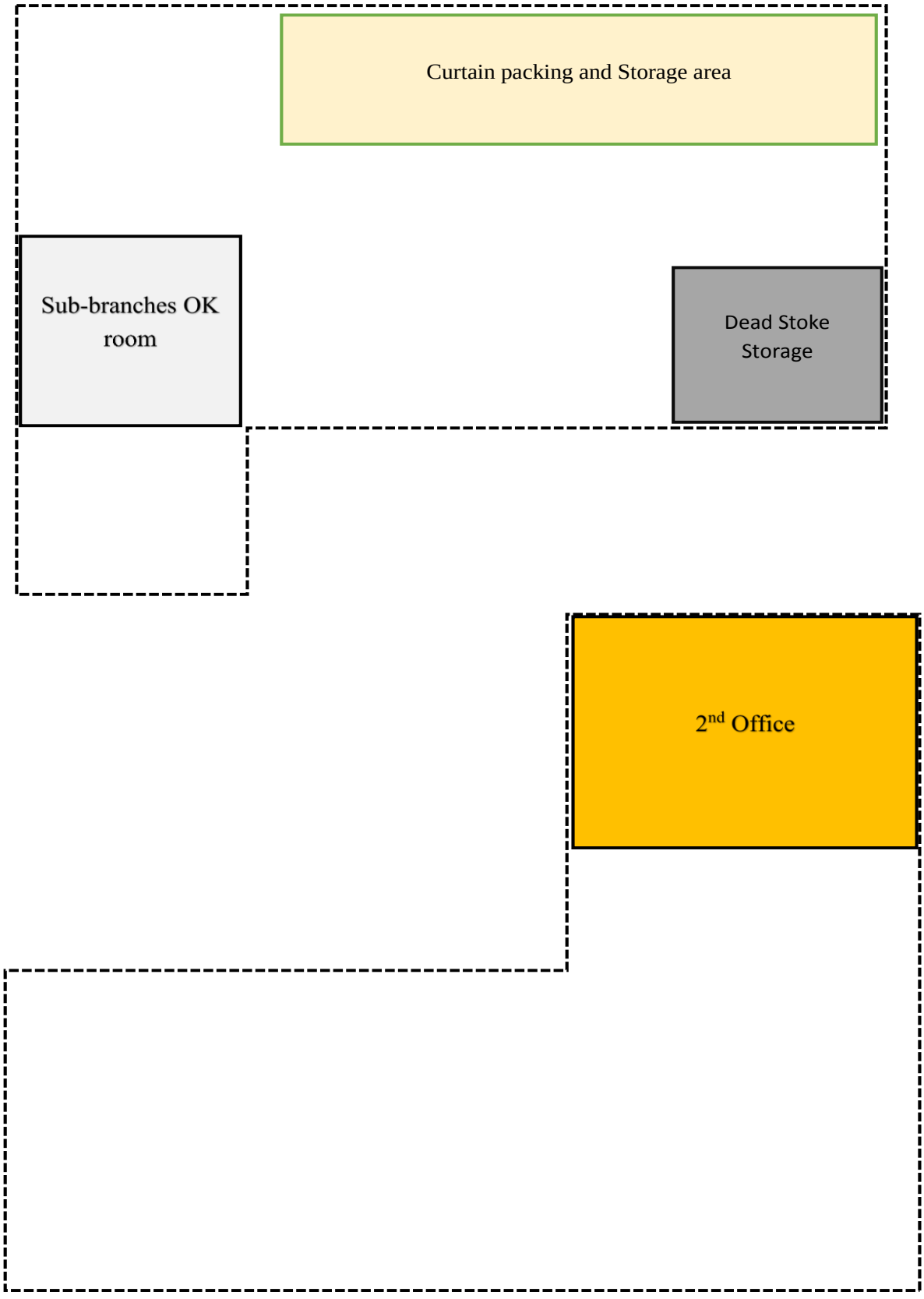
It should be kept in mind that the following schematic dimensionless floor maps are made in accordance to the architectural blueprint of the actual industry. Since the analysis related to the "area wise distribution of processes" i.e. heading 3.3.7, was not concern with the designing or planning of any new facility, department or unit, dimensions of the blue print were not included in the floor maps present in this appendix.

Nevertheless, distribution of processes can be clearly visualize from the following maps, by keeping in mind the processes and activities discussed in process flow chart (see figure 3-1), one can understand and relate processes to their respective locations shown in the maps. Area Data Sheet as per architectural blueprint of the facility is given below for dimensional references for departments.

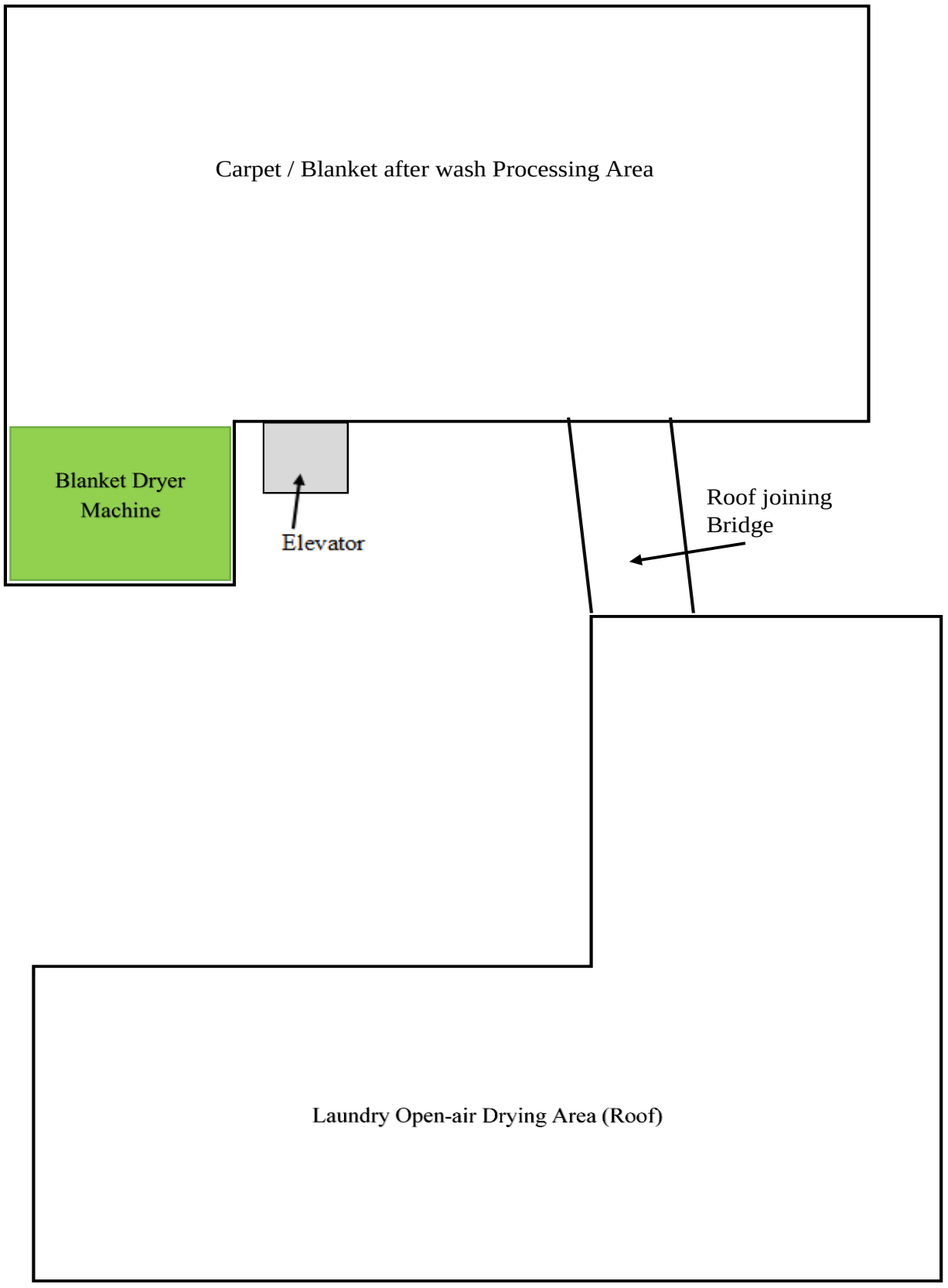
Location / Area name	Dimension L×W (ft. × ft.)	Area in square feet
Ground Floor		
Industrial Footprint	100 × 280	28000
Parking Area	100 × 25	2500
Show room	44.75 × 24.5	1141.12
Steam and Iron Pressing Area	28.75 × 24.5 + 73.5 × 23.5 + 29 × 25	3156.62
Store	14.25 × 23	327.75
Tailor/on-sporting equipment room	9 × 18.8	169.2
Boiler Area (basement)	14 × 23.75	332.5
Washing/Dry Cleaning Area	35.25 × 25.75	907.68
Chemical Store	23.5 × 13.85	325.47
Office	23.5 × 14.25	334.87
Work Shop	23.5 × 89.25	2097.37
Carpet Dusting Area	23.5 × 14.25	334.87
Machinery Store	55 × 58.85	3236.75
Mezzanine Block		
Curtain packing/store Area	44 × 24.5	1078
Sub-branches OK Room	14.25 × 23 + 14 × 23.75	660.25
Dead Stoke Room	9 × 18.8	169.2
Second office Area	23.5 × 28	658
First Floor		
Carpet/Blanket packing/store Area	75 × 49.75 + 29 × 25	4456.25
Blanket Dryer Machine	28 × 13	377
Laundry Open-air drying Area	55 × 58.85 + 25 × 135	6611.75
Roof Top		
Carpet/Blanket Open-air drying Area	75×75	5625


Parking
Ground Floor
Show Room
Steam and Iron Pressing Area
Store
Tailor / On-Sporting Equipment Room
Boiler Area
Elevator
Transportation/Delivery Route
Washing/Dry Cleaning Area
Chemical Store
Office
Workshop
Machinery Storage
Carpet Dusting Machine Area

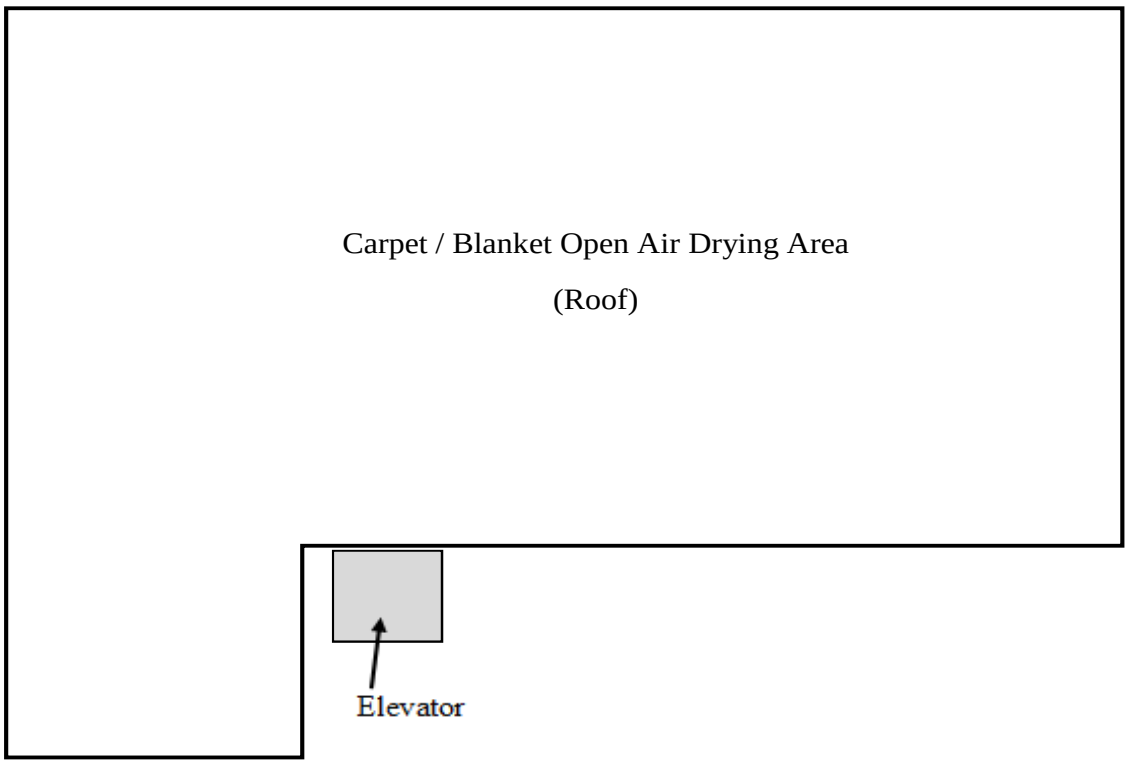
MEZZANINE Block



First Floor


Carpet / Blanket after wash Processing Area
Blanket Dryer Machine
Elevator
Roof joining Bridge
Laundry Open-air Drying Area (Roof)

Rooftop



APPENDIX B

Strategies for Implementing Quality Programs[28]

Sr. no.	Strategies	Description
1	The Quality Award Criteria Approach	This award focuses on the use of criteria such as the Baldrige Award model, President's Award criteria or the Deming Prize to evaluate overall performance
2	The World-Class Company Benchmarking Approach	Individuals or organizational teams visit companies that are leader in continuous quality improvement and determine what success they have had and how they accomplished it
3	The Employee Involvement-Based Approach	This approach focuses on using the strengths and suggestions of human resources to embark on continuous quality improvement efforts
4	The Customer-Driven Improvement Approach	Customer suggestions and statements of requirements are used to develop improvement strategies for product and services
5	The Total Quality Systems Approach	It focuses on the key systems, tools and techniques for achieving quality and productivity improvement
6	The Japanese Total Quality Approach	Organizations study the successful implementation strategies and techniques used by the Deming Prize-winning companies and use this experience to develop short-term and long-term continuous quality improvement plans
7	The Guru Approach	It uses the theories, principles, teachings and lessons of a leading quality expert. The only drawback is that no guru has all the answers to organizational, cultural and business problems

Crosby's Quality Management Maturity Grid[28]

Measurement Categories	Stage 1: Uncertainty	Stage 2: Awakening	Stage 3: Enlightenment	Stage 4: Wisdom	Stage 5: Certainty
Management understanding and attitude	Fail to see quality as management tool	Support quality in theory but unwilling to provide necessary investment (money or time)	Learn about quality management and become supportive	Participate personally in quality activities	Regards quality management as essential for company success
Quality organization status	Quality activities are limited to manufacturing or engineering department and are largely appraisal and sorting	A strong quality leader is appointed, but quality activities remain focused on appraisal and sorting and are still limited to manufacturing or engineering department	Quality department report to top management, and its leader is active in company management	Quality manager is an officer of the company. Prevention activities have become important	Quality manager is on the board of directors. Prevention is the quality activity
Problem handling	Problems are fought as they occur and are seldom fully resolved	Teams are established to attack major problems, but the approach remain short term	Problems are resolved in an orderly fashion, and corrective action is a regular event	Problems are identified early in their development	Problems are prevented, except in the most unusual cases
Cost of Quality As percentage of sales	Reported: unknown Actual: 20%	Reported: 5% Actual: 18%	Reported: 8% Actual: 12%	Reported: 6.5% Actual: 8%	Reported: 2.5% Actual: 2.5%
Quality Improvement action	No organized activities	Activities are motivational and short-term	Implements the 14-step program of Crosby, with understanding	Continues of 14-step program, starts Make Certain	Improvement is a regular and continuous action
Summation of company quality posture	We do not know why we have quality problems	Must we always have quality problem?	Because of quality management and improvement programs, we are identifying and resolving quality problem	We routinely prevent defects from occurring	We know why we do not have quality problems

Source: Quality is Free (New York: McGraw-Hill, 1979)

Perspectives on Quality[28]

Perspectives	Crosby's Philosophy	Juran's Philosophy	Deming's Philosophy
Area of Focus	Organization-wide, treats it as a whole living organism	Three main Areas: quality planning, control and improvement	Puts quality in human terms
Emphasizes upon	Controlling the cost of Quality	The combine improvement efforts by these three	Organization's workforce and managerial process
Number of Steps / areas / points	Outlined fourteen steps	Identified seven areas	Proposed fourteen points
Steps / Areas / Points of Each Philosophy			
1	Management Commitment	Breakthrough in Attitudes	Create constancy of purpose of improvement of product and services
2	Quality Improvement Team	Identify the vital few projects / problems	Adopt the new philosophy
3	Quality Measurement	Organize for breakthrough in knowledge	Cease dependence upon mass inspection
4	Cost of Quality Evaluation	Conduct the Analysis	End the practice of awarding business on the price tag alone
5	Quality Awareness	Determine how to over-come resistance to change	Improve constantly and forever the system of production and service
6	Corrective Action	Institute the change	Institute training
7	Zero-Defect training	Institute controls	Institute leadership
8	Supervisory training	____	Drive out fear
9	Zero-defect Day	____	Break down barrios between staff areas
10	Goal Setting	____	Eliminate slogans, exhortations, and targets for work force
11	Error Cause Removal	____	Eliminate numerical quotas
12	Recognition	____	Remove barrios to pride of workmanship
13	Quality Councils	____	Take action to accomplish the transformation
14	Do it All Over Again	____	Institute a vigorous program of education and retraining

APPENDIX C

OSHA's 29 CFR 1910.134 [53]

A standard given by Occupational Safety and Health Administration (OSHA), Standard number is: 1910.134; title: Respiratory Equipment; Government Public Office (GPO) source: Electronic Code of Federal Regulations (e-CFR).

Use for the control of occupational diseases caused by breathing air contaminated with harmful dusts, fogs, fumes, mists, gases, smokes, sprays, or vapors, the primary objective shall be to prevent atmospheric contamination

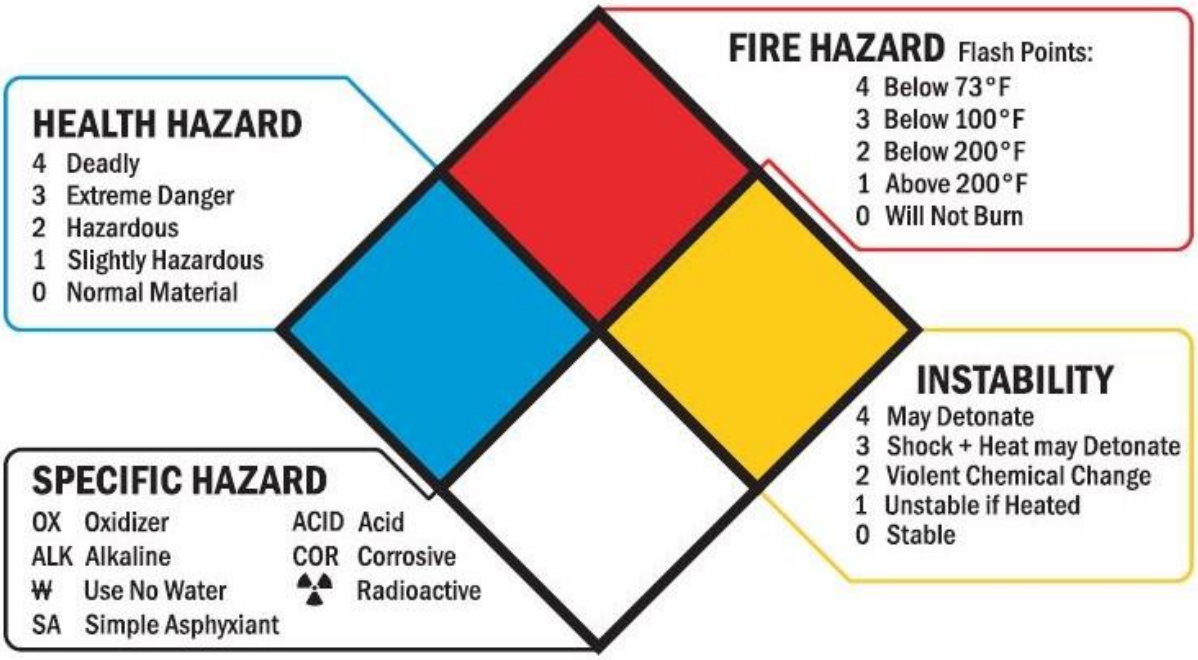
ANSI/ASSE Z88.2 [54]

A Standard given by American National Standards Institute (ANSI), minimal accepted practices for occupational respirator use, provides information and guidance on the proper selection, use and maintenance of respirators and contains requirements for establishing, implementing and evaluating respirator programs. It covers personal protection against the inhalation of harmful air contaminants and against oxygen-deficient atmospheres in the workplace.

European Standard EN 149 [55]

This European Standard specifies minimum requirements for filtering half masks as respiratory devices to protect against particles. Laboratory and practical performance tests are included for the assessment of compliance with the requirements.

National Fire Protection Association (NFPA) classification for materials in MSDS[59]

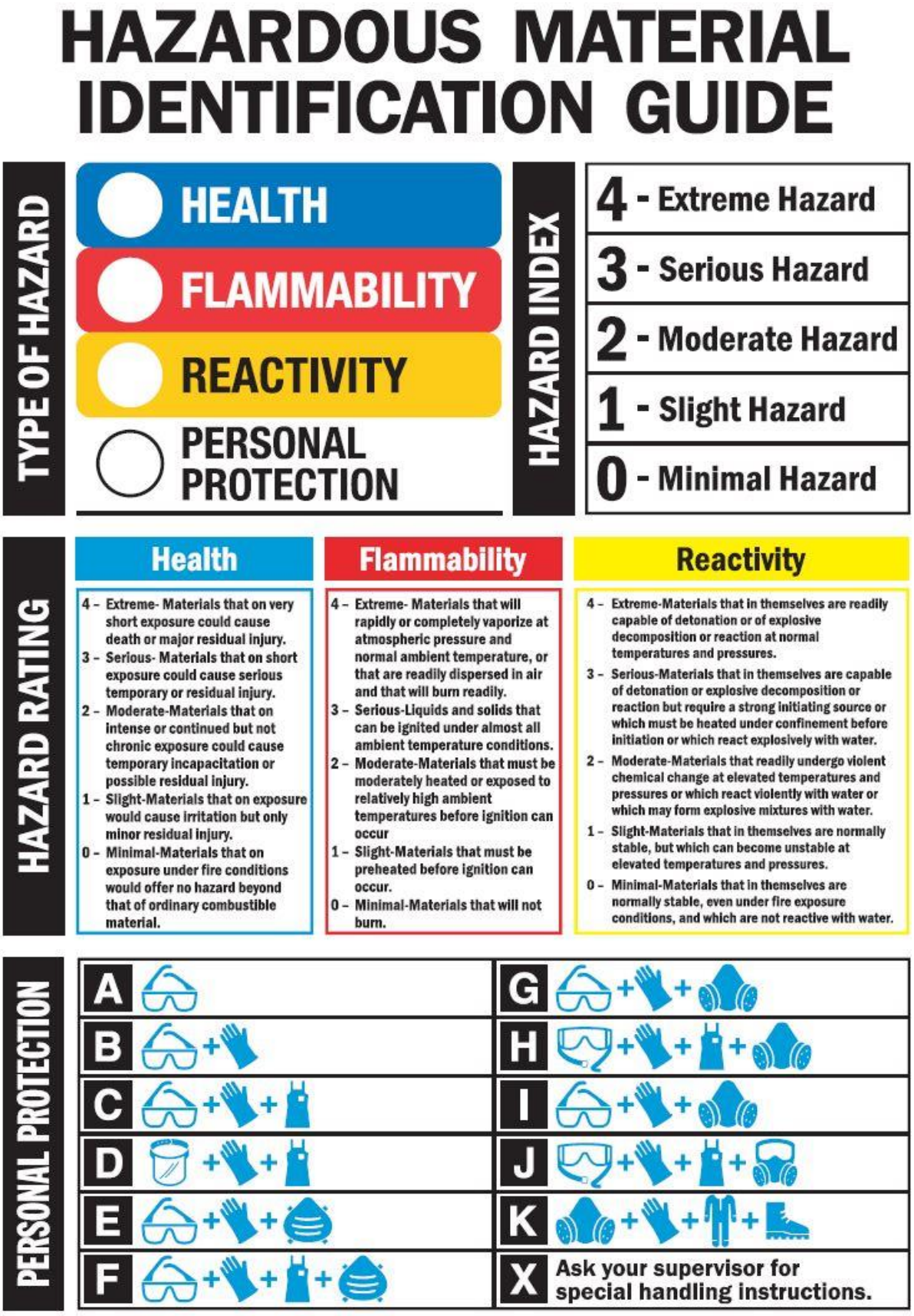


CONSULT MSDS FOR FURTHER INSTRUCTIONS

RATING EXPLANATION GUIDE

HEALTH		FLAMMABLE		INSTABILITY	
Recommended Protection		**Susceptibility to Burning**		**Susceptibility to Energy Release**	
4	Special full protective suit and breathing apparatus must be worn.	4	Very flammable.	4	May detonate under normal conditions.
3	Full protective suit and breathing apparatus should be worn.	3	Ignites under normal temperature conditions.	3	May detonate with shock or heat.
2	Breathing apparatus with full face mask should be worn.	2	Ignites with moderate heating.	2	Violent chemical change but does not detonate.
1	Breathing apparatus may be worn.	1	Ignites when preheated.	1	Not stable if heated use precautions.
0	No precautions necessary.	0	Will not ignite.	0	Normally stable.

NFPA Hazardous material Identification Guide[60]



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